Iron and Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

AUGUST, 1951

TABLE OF CONTENTS, Page 49

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AUG 29 1951
DETROIT

MESTA-THOMSON Flash Welders for Increased Cold Mill Production

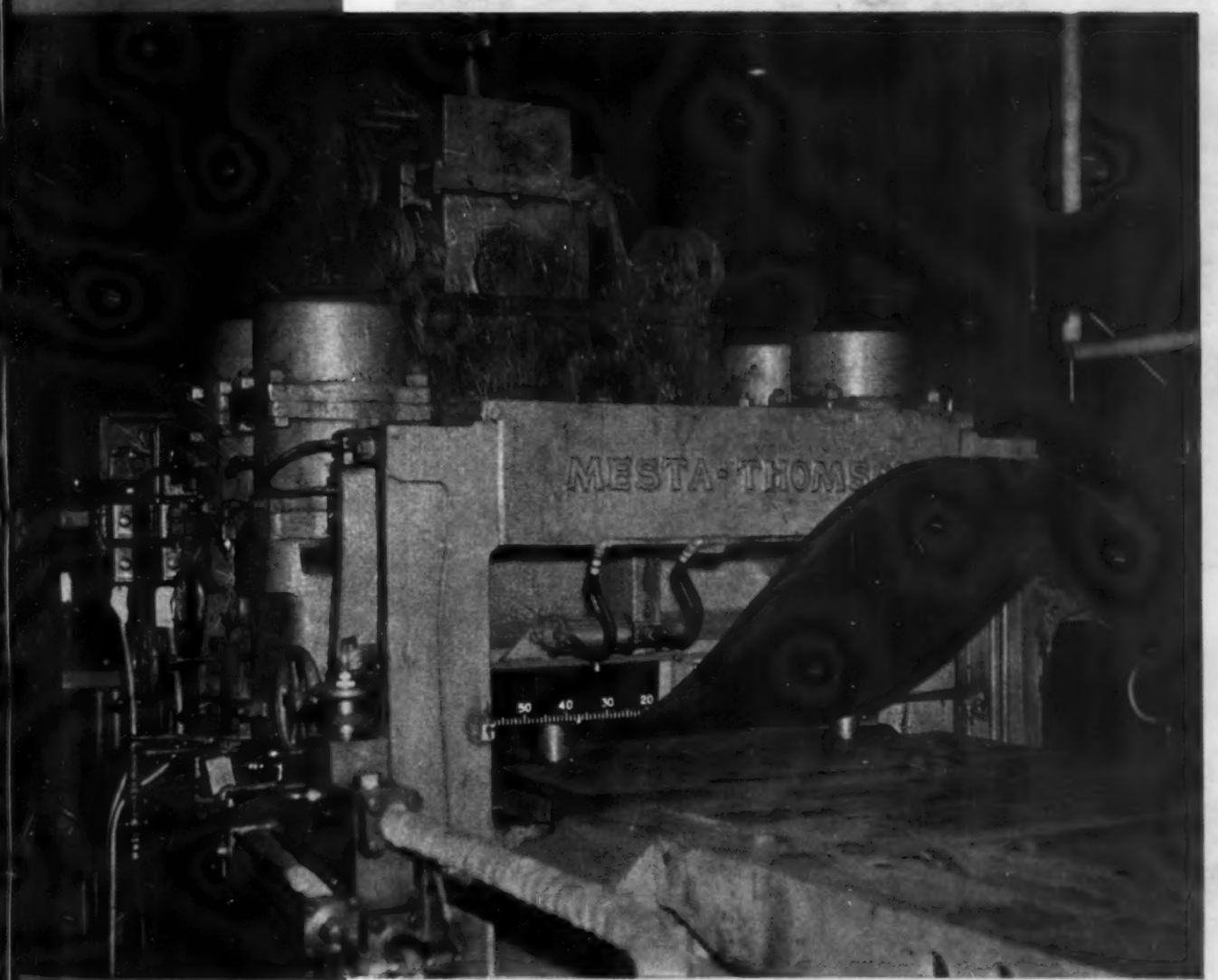


Photo by E. D. MESTA

42" Mesta-Thomson Flash Welder in a Mesta High-Speed Continuous Pickling Line installed at the Aliquippa Works of Jones & Laughlin Steel Corporation.

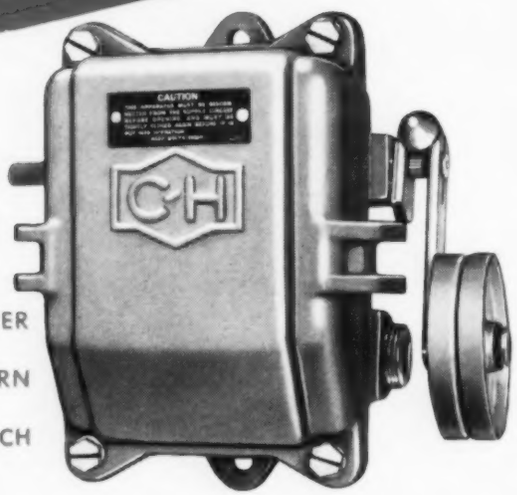
DESIGNERS AND BUILDERS OF COMPLETE STEEL PLANTS

MESTA MACHINE COMPANY · PITTSBURGH, PA.

CUTLER-HAMMER

new TRACK TYPE limit switches

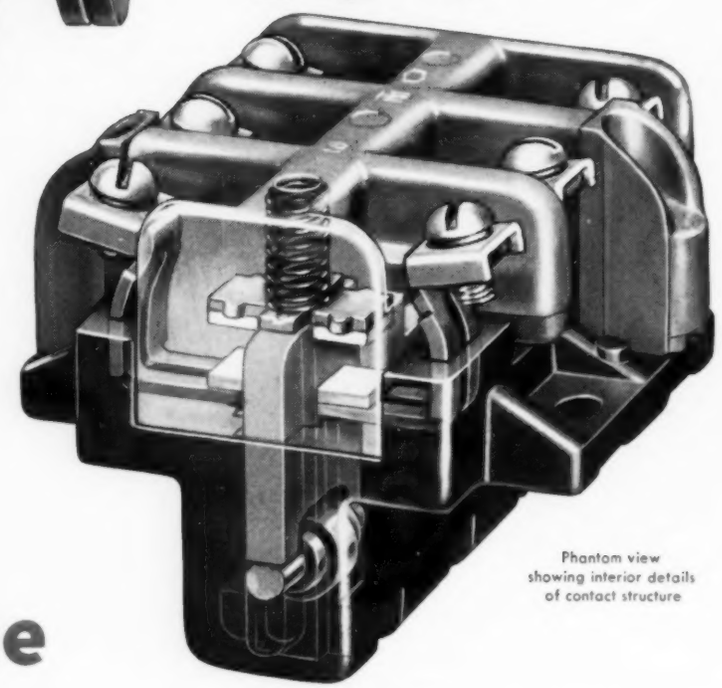
(Bulletin 14977)



ROLLER LEVER SPRING RETURN SWITCH

FORK LEVER TWO POSITION SWITCH

Clamp-on type operating lever can be mounted at any angle on shaft. Also can be readily shifted to opposite end of shaft for right or left hand track installation. Overtravel provided in both directions. Cast iron NEMA 1 Standard, NEMA 4 Watertight or NEMA 5 Dusttight enclosures. Tapped for conduits. Contacts rated at 1.25 amps. at 250 volts d.c. Two pole or three pole with contacts normally open and/or normally closed, with or without overlap.



Phantom view showing interior details of contact structure

utilizing the all new simplified contact structure

CUTLER-HAMMER
MOTOR CONTROL
C-H

STANDARDIZED . . . the identical contact structure used in many other Cutler-Hammer limit switches, mill accessory masters, foot switches, etc. It is *completely* interchangeable . . . simplifies spare parts and replacement problem.

SIMPLIFIED . . . this contact structure is reduced to simplest elements, for easy understanding, for easy accessibility, for easy parts renewal.

STURDY . . . cam and roller actuated, long-lived, dependable. Small and compact. Many features, special alloy tips, arc-resistant molded supports, twin break contacts, etc., etc., etc. CUTLER-HAMMER, Inc., 1269 St. Paul Ave., Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto.

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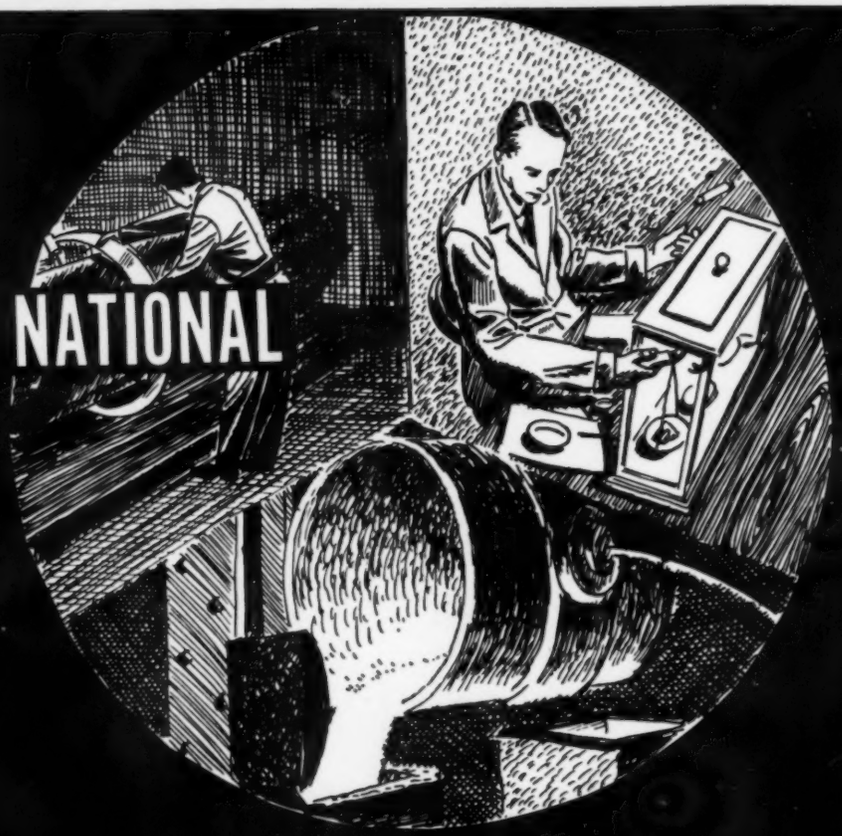
Care AT NATIONAL Saves Wear ON YOUR STANDS



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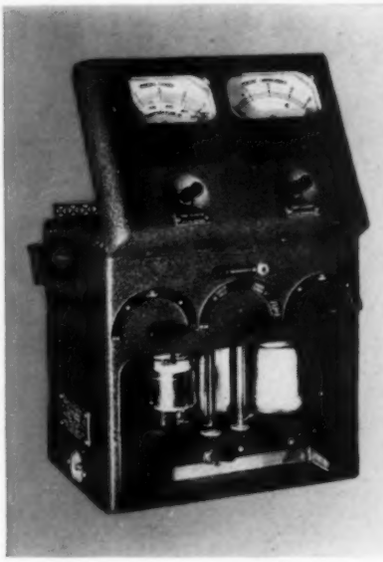

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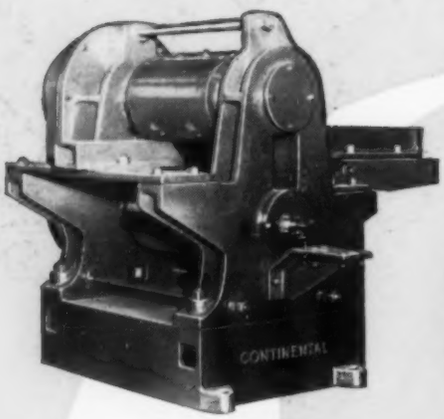


Cropping and Dividing Shear

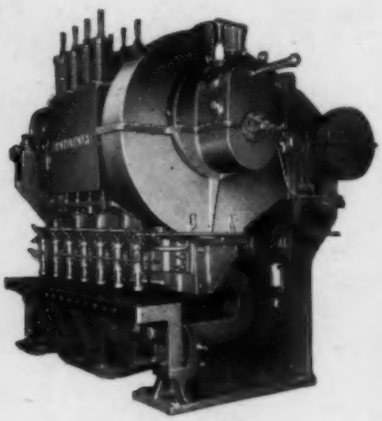
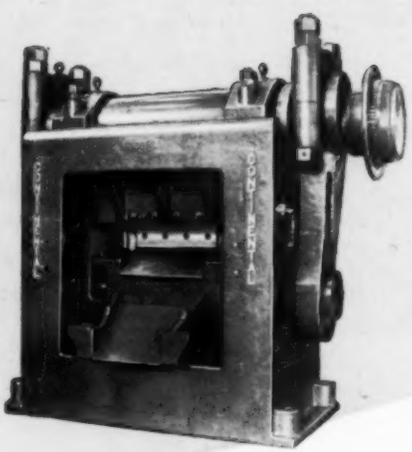


Plate Shear



Upcut Bloom Shear

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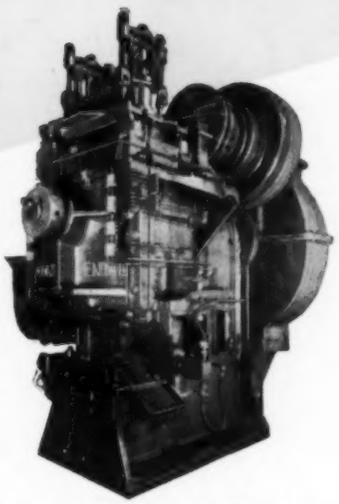
Blooming Mills	Plate Mills	Non-Ferrous Mills	Tables
Structural Mills	Slabbing Mills	Roll Lathes	Transfers
Bar Mills	Universal Mills	Ingot Mold Cars	Shears and other auxiliary steel plant equipment
Billet Mills	Hot Strip Mills	Charging Box Cars	
Merchant Mills	Cold Strip Mills	De-Pilers	

IRON, ALLOY IRON and STEEL ROLLS for ferrous and non-ferrous rolling mills; pulp and paper industry; textile industry; and milling, cereal and vegetable oil industries.

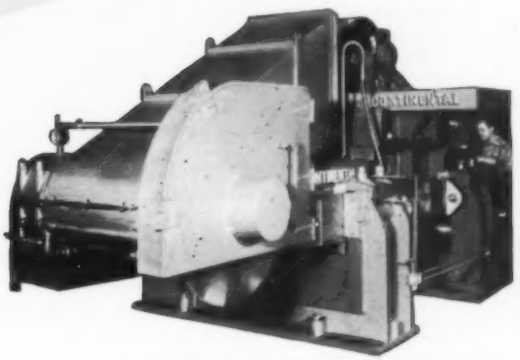
CARBON and ALLOY STEEL CASTINGS from 20 to 250,000 pounds. Complete heat treating and machining facilities.

Downcut Slab Shear and Gauge

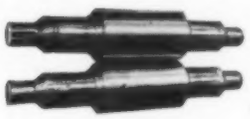
Straightening Press



Tie Plate and Splice Bar Punch and Shear



Heavy Duty Hot and Cold Saw



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Continental

FOUNDRY & MACHINE CO.

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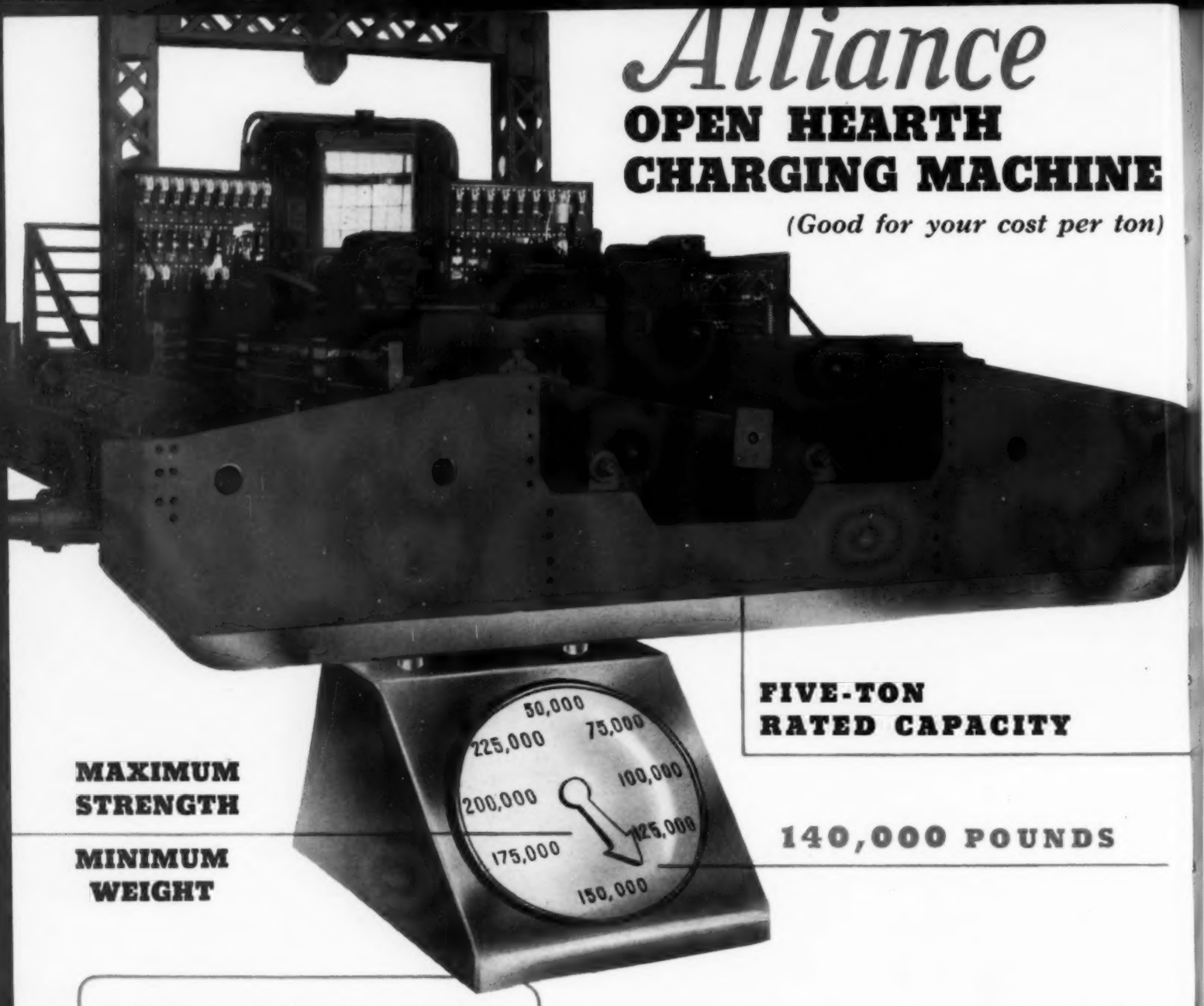
OPEN HEARTH CHARGING MACHINE

(Good for your cost per ton)



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MAXIMUM STRENGTH

140,000 POUNDS

MINIMUM WEIGHT

with these exclusive *Alliance* features

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- ★ All gears fully enclosed and run in oil.
- ★ Girders are made of two wide-flange beams welded together to form a box section and reinforced by diaphragms.
- ★ Machinery deck riveted to bottom flange of main and auxiliary girder keeps machine in perfect alignment.

● This new 5-ton capacity open hearth Charging Machine has all the special features found in larger Alliance Machines.

This all-welded Charging Machine replaced obsolete charger and required no building reinforcements due to its lighter weight. **Strength was not sacrificed.**

Alliance, world's largest builder of the world's largest cranes, has developed many special machines for moving unusual loads for heavy industries.

Alliance Engineers will be happy to discuss your specific requirements or give you general information of interest to your specific industry. Contact Alliance today.

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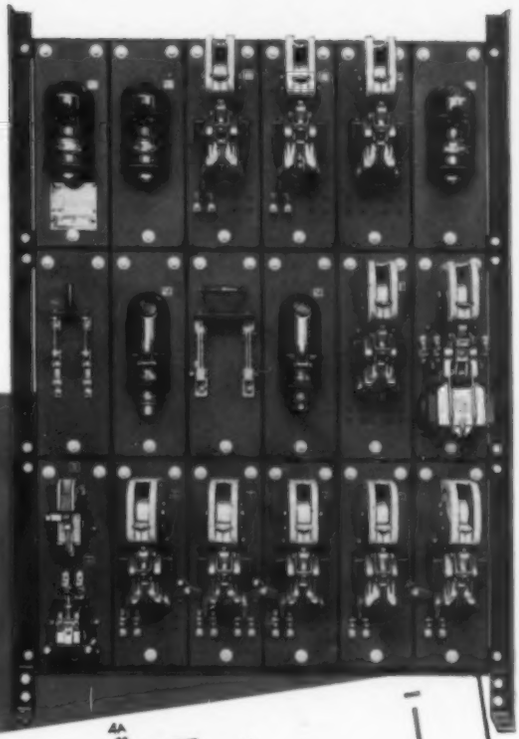
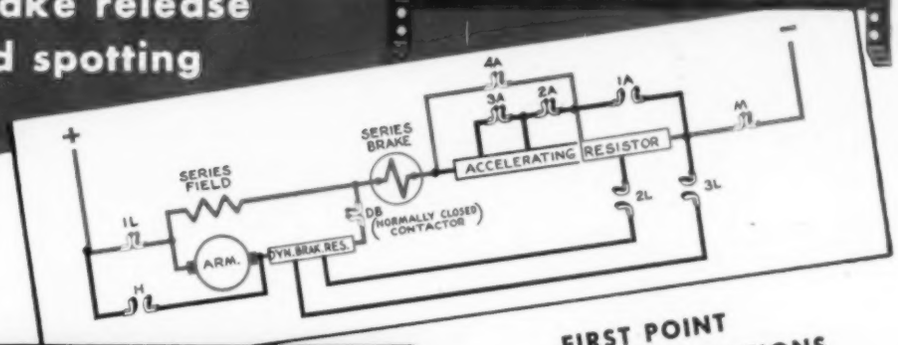
8 *Important Features of* **EC&M** *Magnetic Control*

1. Time-Current Acceleration
2. Line-Arc Contactors
3. Wright Hoist Circuit
4. Tab-Weld Resistors
5. Cam Master Switches
6. Safer Electrical Interlocks
7. Bolted, Welded Frame
8. Quick Contact Renewing

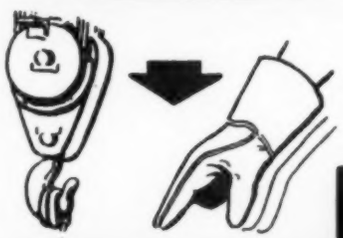


THE WRIGHT DYNAMIC LOWERING CIRCUIT FOR CRANE HOISTS

1. gives fast brake release
2. accurate load spotting



FIRST POINT LOWERING CONNECTIONS



Where good inching means fewer movements— reduced wear

The EC&M Wright Circuit for Crane Hoists is well-known for its ability to spot a heavy load accurately.

Look at the diagram of the first point lowering connections. Note the line in red showing that all the current taken from the line goes through the brake coil for fast brake release. Combined with fast operating LINE-ARC Contactors, the loaded crane-hook can be inched down with ease. A heavy load is carefully landed—with a minimum number of movements which maintenance men recognize as a contributing factor to reduced upkeep and wear.

When buying cranes, specify EC&M Magnetic Control.

THE ELECTRIC CONTROLLER & MFG. CO.
2698 EAST 79TH STREET • CLEVELAND 4, OHIO

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CLOSE TOLERANCE
TONNAGE

feature this Rod and Bar Mill by...

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ROLLS AND ROLLING MILL EQUIPMENT
FOR THE IRON, STEEL AND
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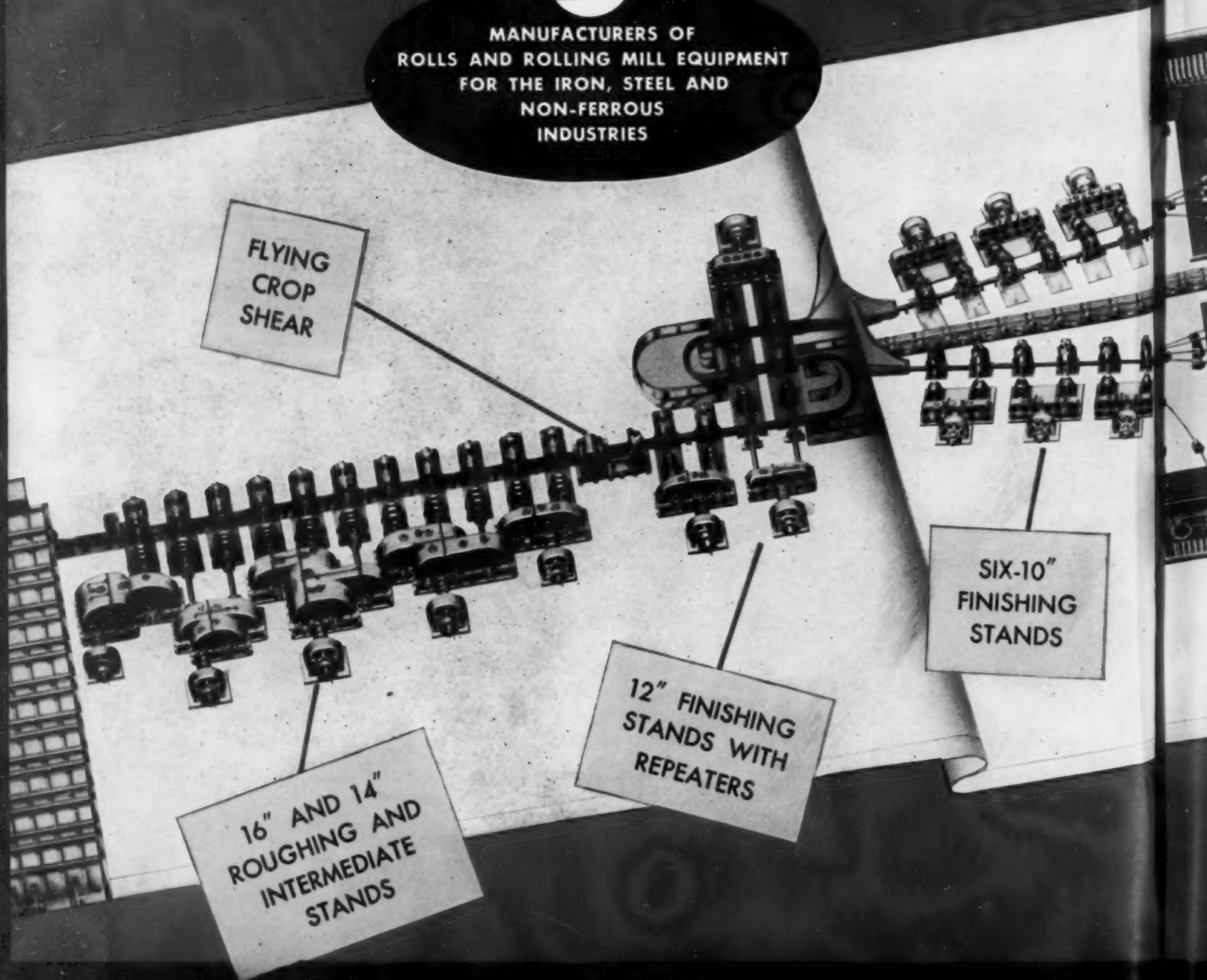
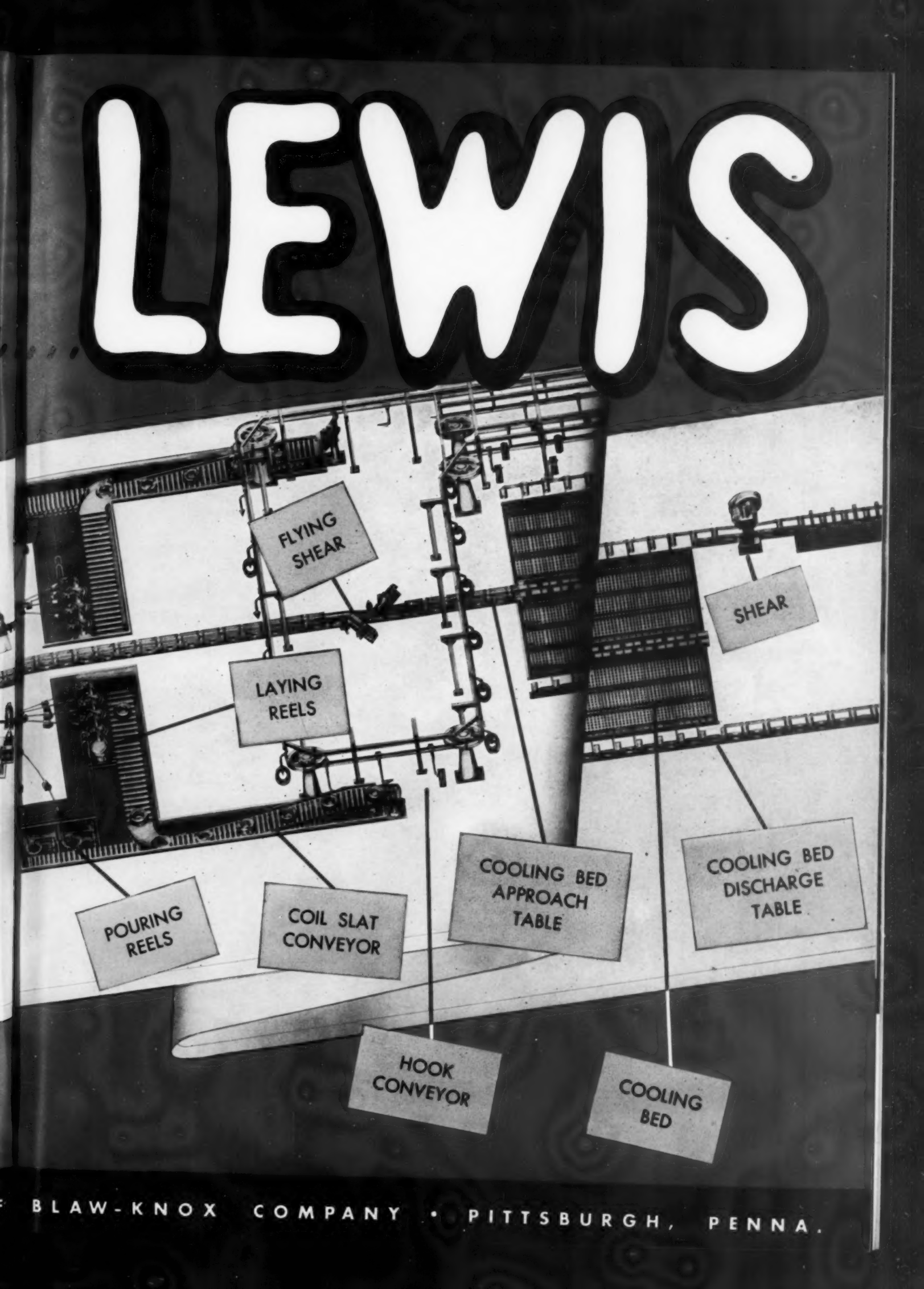

FLYING CROP SHEAR
16" AND 14" ROUGHING AND INTERMEDIATE STANDS
12" FINISHING STANDS WITH REPEATERS
SIX-10" FINISHING STANDS

LEWIS FOUNDRY AND MACHINE DIVISION OF BL



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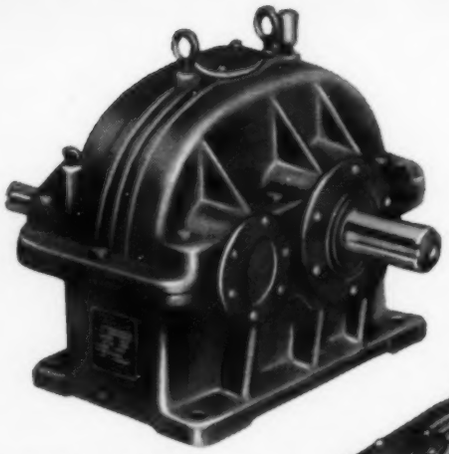
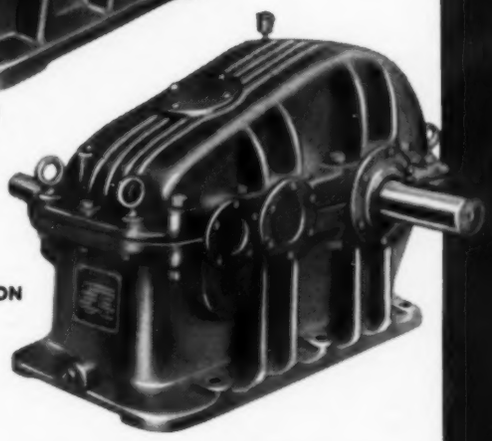
PITTSBURGH ROLLS DIVISION OF BLAW-KNOX COMPANY • PITTSBURGH, PA.



SINGLE REDUCTION



DOUBLE REDUCTION

COMPACT

MORE POWER IN LESS SPACE!

TRIPLE REDUCTION

FOOTE BROS. MAXI-POWER PARALLEL SHAFT HELICAL GEAR DRIVES

MORE POWER – LESS SPACE – Precision processed gearing, improved materials and heat-treatment, closer manufacturing tolerances, permit selection of smaller size, lower weight units.

IMPROVED PERFORMANCE – Generated helical gearing of maximum accuracy for uniform load distribution—positively located gearing for full tooth engagement across entire gear face—all mean better performance.

SMOOTH OPERATION – Overlapping tooth action of highly accurate helical gearing—close backlash tolerances—reinforced housing design plus extra capacity **Antifriction Bearings Throughout** provide smooth, quiet operation.

42 SIZES – Single, double and triple reductions, ratios from 2.08 up to 360 to 1—capacities up to 1,550 h.p. provide the correct unit for practically any application.

A Foote Bros. enclosed gear drive for any industrial application. Foote Bros. will gladly consult with you on your enclosed gear drive requirements.

LINE-O-POWER DRIVES

HYGRADE DRIVES

FOOTE BROS.-LOUIS ALLIS GEARMOTORS

FOOTE BROS.

Better Power Transmission Through Better Gears

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FOOTE BROS. GEAR AND MACHINE CORPORATION
Dept. IAS; 4545 Western Blvd., Chicago 9, Ill.

Send me Bulletin MPB on Foote Bros. Maxi-Power Drives.

Name.....

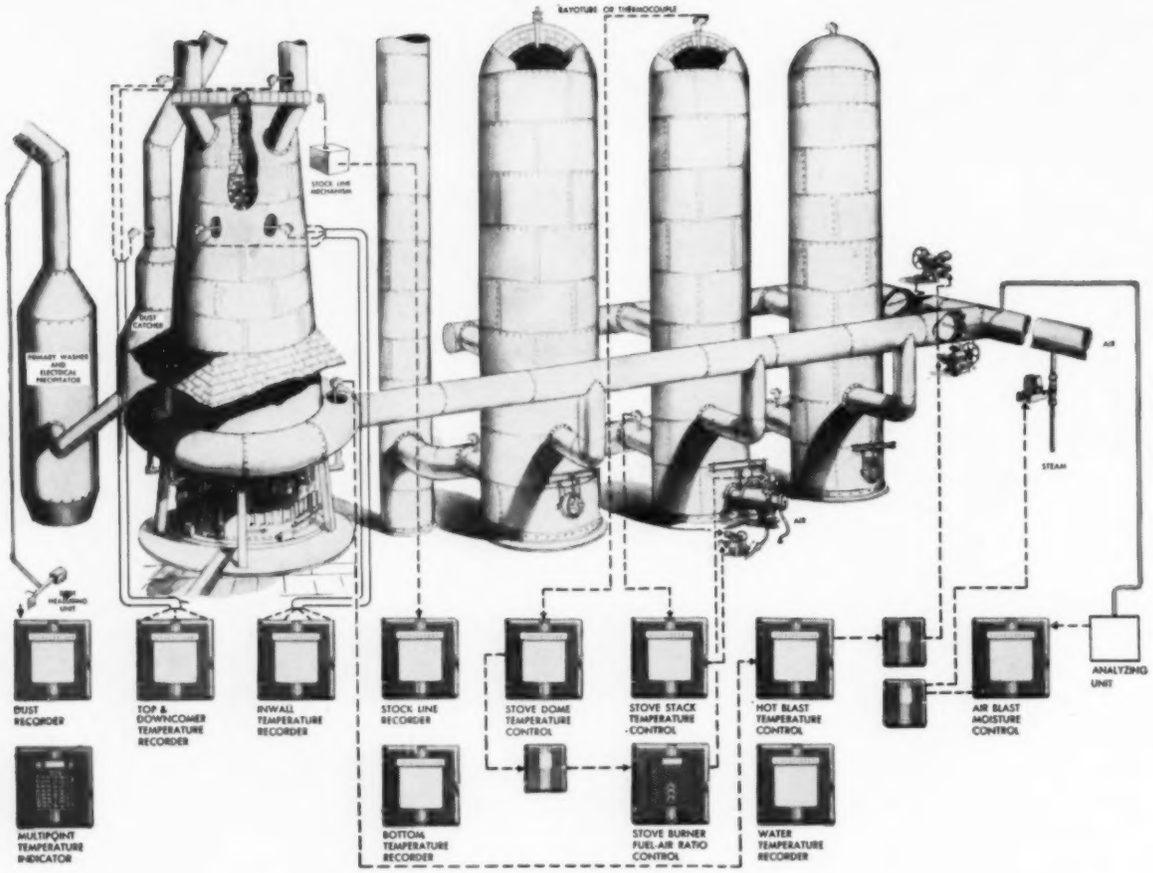
Company.....

Position.....

Company Address.....

City..... *Zone*..... *State*.....

Key instruments for increasing



L&N can serve you from charging platform to mixer

When you're building a new furnace —or trying to get more tonnage from an existing one—here's news about the latest in blast furnace instrumentation. The L&N equipment shown here can definitely help you get greater tonnage . . . meet closer specs . . . despite shortages of material and inexperienced manpower.

Here's why!

(1) Practical blast furnace men have played a part in developing these instruments. They are designed specifically for blast furnace control . . . not just "adapted" to it.

(2) More "variables" than ever before can now be controlled automatically. Fluctuations are headed off faster . . . more easily. Manpower is used more efficiently. For each key point, there's an L&N instrument exactly fitted for that particular job.

(3) In addition to being designed and built correctly, this equipment is applied correctly. Every installation benefits by the "know-how" accumulated during 40 years of work with the steel industry's production men, engineers, metallurgists and instrument technicians.

Probably you're using some of these instruments now. Others will be familiar to you. A few are brand new. Correctly engineered and applied, they're among the soundest, most advanced tools for making *more* iron . . . *better* iron.

LEEDS & N

blast-furnace tonnage

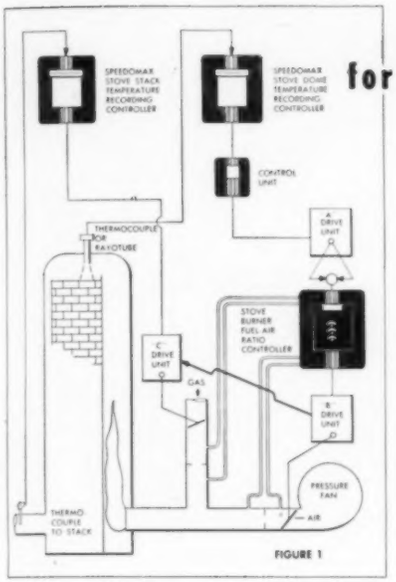


FIGURE 1

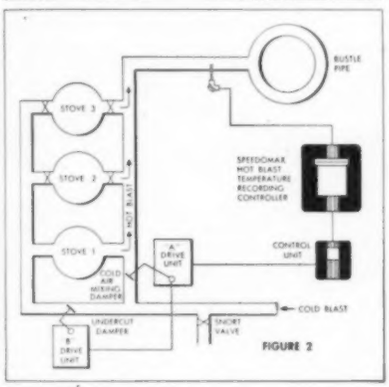


FIGURE 2

don't miss "sequence" controls for blast furnace stoves

Because of great heat capacity, modern blast-furnace stoves are easier to operate when the familiar one-drive-unit automatic control is replaced by L&N Sequence-Type Control. It applies both to Stove Heating and to Blast Heating.

Stove Heating, Fig. 1. With stove on gas, Stove Burner Fuel-Air Ratio Controller maintains fuel efficiency until dome reaches top temperature. Then Stove Dome Temperature Controller uses Drive Unit "A" to re-set Ratio Controller, which puts in excess combustion air by Drive Unit "B", thus cooling the stove flame.

If stove dome temperature still rises, sequence action comes in and Drive Unit "B" passes control to "C", which throttles gas directly. Finally, when stove is fully heated, Stack Controller is last in sequence; it cuts gas back to preset level and holds stove at temperature until needed.

Advantages:

1. High combustion efficiency
2. Long stove life
3. Warning of need for stove repair

Blast Heating, Fig. 2. Suppose Stove 1 is going on air. Its blast is too hot at start; Speedomax uses Drive Unit "A" to open air-mixer valve and reduce temperature. However, the blast is still probably too hot, and Drive Unit "B" picks up control sequence. It throttles undercut damper, forcing more air through the cold air mixing damper until temperature is right.

Then, as stove cools, control action is reversed; undercut damper is moved toward open, then mixer damper is moved toward closed, forcing more air through the stove and continuing until stove goes off air.

Advantages:

1. The "bump" of a hot stove is reduced.
2. Operator does not have to nurse stove.

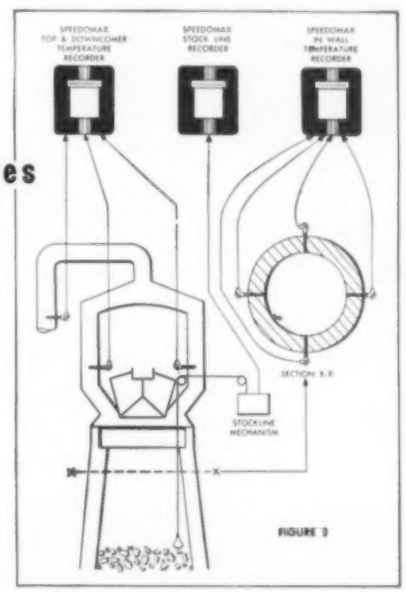


FIGURE 3

list of recorders for blast furnaces has recent & valuable additions

Speedomax Burden Recorder

Information about the motion of a blast furnace's burden is amply important, in the opinion of many superintendents, to justify the use of Speedomax Recorders as members of the team for helping the blast furnace produce more iron in less time.

Recorder Fights "Dirty" Gas

Many a "dirty gas" complaint can be headed off by using a Speedomax Dust Recorder. Regardless of cause of dirt, this instrument tells the gas plant promptly.

Speedomax Recorders for Top & Downcomer

A continuous record of top and downcomer temperatures enables operator to tell whether he should adjust blast pressure, change charging rate, or make some other correction.

Inwall Temperature Speedomax

This Speedomax Recorder helps prevent gas channeling and possible blow-through.

Recorder Saves Cooling Water

This Speedomax Recorder helps end over-cooling and resulting waste of water; warns of any overheating.

Quick Temperature Roundup With Indicator

A temperature "tour" of a hundred or more thermocouples can be taken in just a few minutes with a multiple-point Speedomax Indicator.

NORTHRUP CO.

LEEDS & NORTHRUP CO.
4942 Stenton Ave., Phila. 44, Pa.

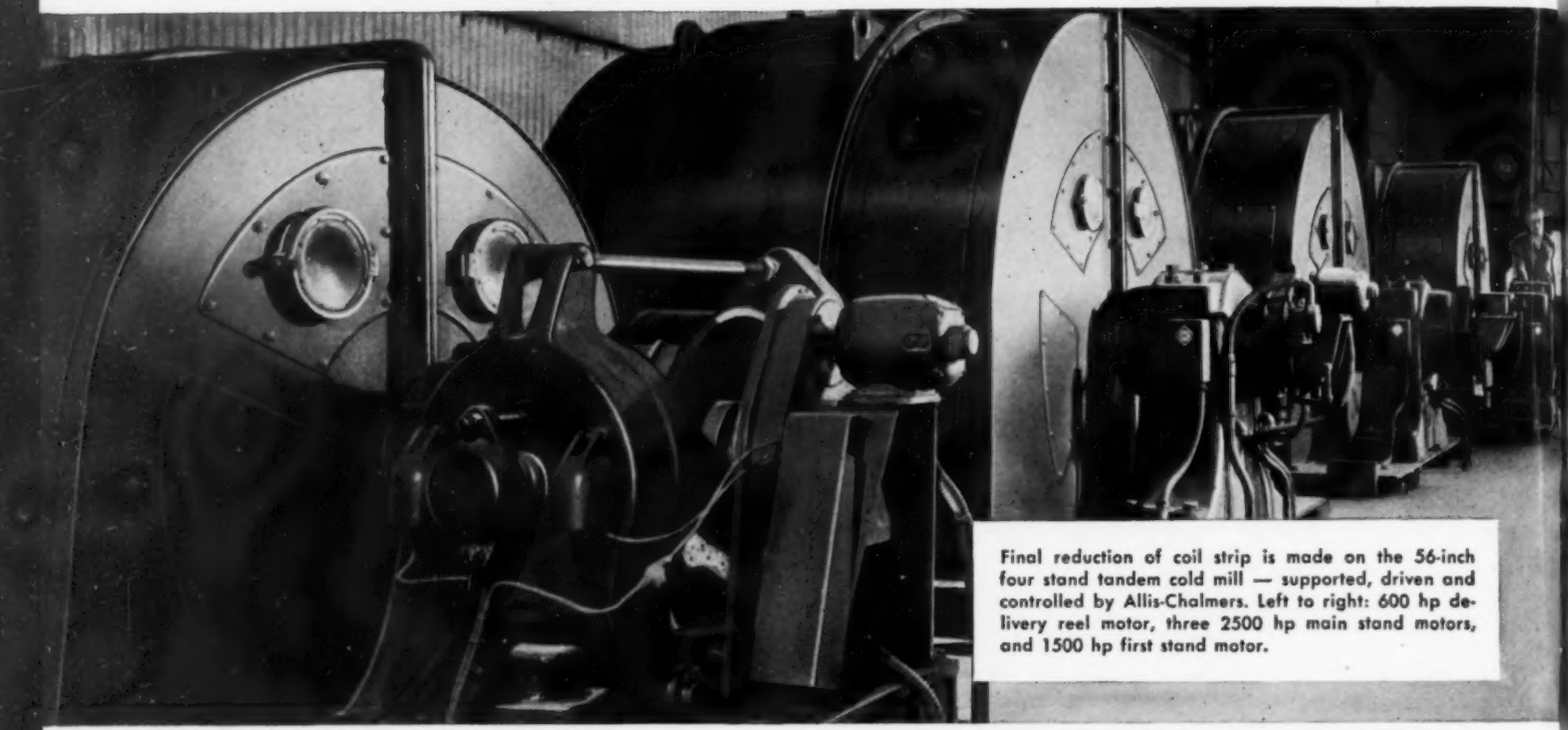
Please send bring information about instruments for the following:

(Name) (Title)

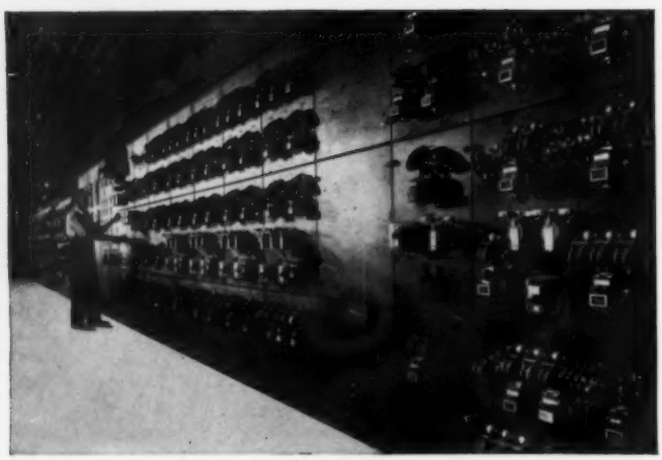
(Firm)

Jri. Ad N-642(1)

ALLIS-CHALMERS SPEEDS

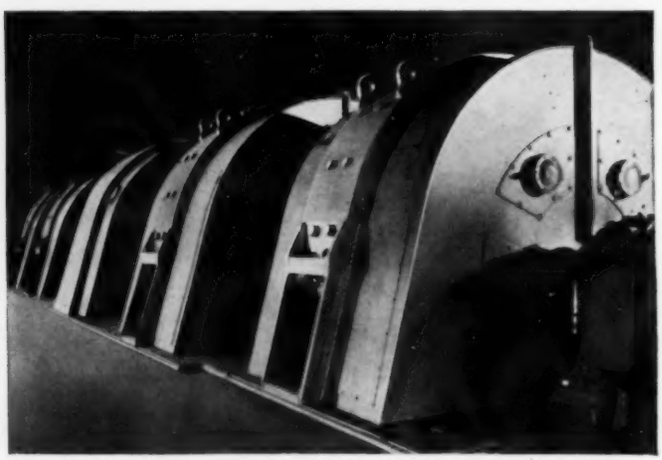


Final reduction of coil strip is made on the 56-inch four stand tandem cold mill — supported, driven and controlled by Allis-Chalmers. Left to right: 600 hp delivery reel motor, three 2500 hp main stand motors, and 1500 hp first stand motor.



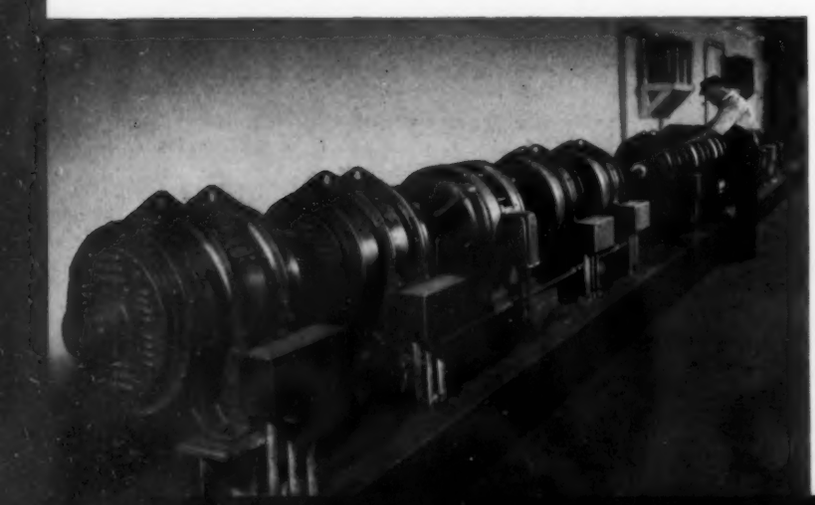
Variable voltage dc control board for 56-inch tandem cold mill. Allis-Chalmers supplied all controls and switchgear — as well as the main and auxiliary drives — for processing the steel from the hot mill to shipping.

Regulex rotating amplifier exciter sets provide variable voltage dc control of the drive motors and M-G set. Wide use is made here of *Regulex* exciter sets to control tension, reel buildup and speed matching.



The individual generator system of support and control is employed on the cold reduction mill, which was first placed in operation in 1947. The Allis-Chalmers supporting 7-machine, 7750 kw M-G set is seen here.

These three Allis-Chalmers 4000 kva oil immersed, self-cooled transformers handle the incoming power for the cold mill. Transmission power at 69 kv is transformed to 6900 volts for the synchronous M-G set.



SINCE
GRANITE CITY STEEL
1878

STEEL ROLLING

AN AGGRESSIVE, UNAFRAID APPROACH to increased demand is typical of the Granite City Steel Company. Completing a $26,000,000 expansion only two years ago, and with a $6,000,000 program nearing completion, the company now has announced a further $50,000,000 expansion! Capacity — mostly in coils, sheets and tinplate — will then be well over a million tons a year.

Operations pictured were included in the recently completed expansion. They illustrate the wide range of equipment Allis-Chalmers has supplied the Granite City Steel Company and offers to the American steel industry in its expansion efforts.

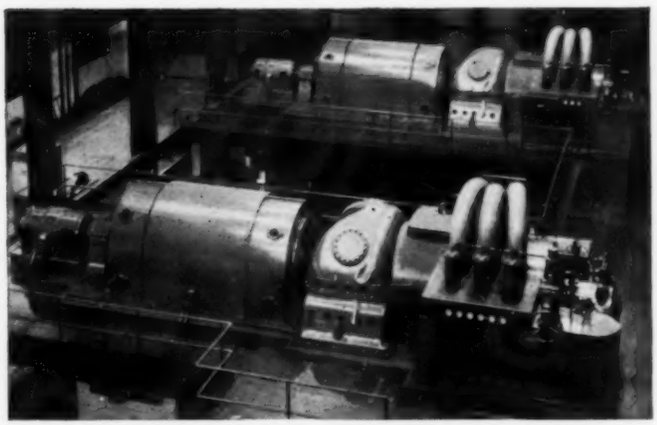
Complete electrical equipment — from the hot strip mill to shipping — was supplied by Allis-Chalmers! This broad, quality line of equipment has proved so satisfactory that the steel company has specified Allis-Chalmers substations and power transformers, as well as drives, controls and auxiliaries for the roughing and reversing blooming mills, for the *next* expansion program.

Constant growth has characterized this progressive midwestern company ever since its founding in 1878. During that time steel rolling at Granite City has gone from single stand, two high hand mills of under a ton per hour capacity to the modern four stand, four high tandem cold mill (left) of 45 tons per hour capacity.

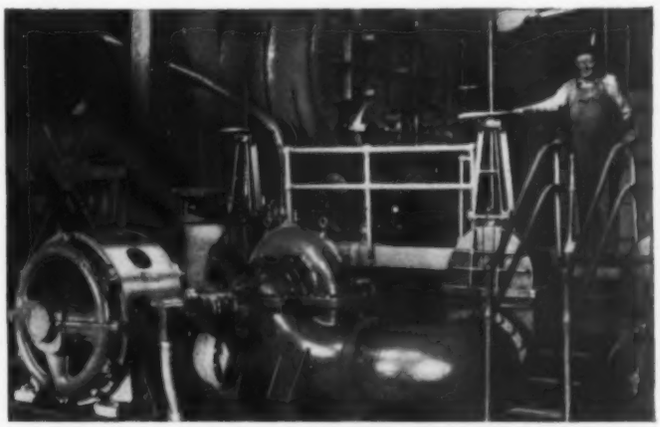
Strip is tempered (space not permitting illustration) on either a 48 or 56-inch temper mill . . . both of which are also Allis-Chalmers driven, supported and controlled. All electrical equipment for processing — including pickling, cleaning, tinning, and shearing — also is A-C supplied.

Your conversion or expansion program also can benefit from Allis-Chalmers wide experience in building and applying electrical equipment in the iron and steel industry. Integrated design and unit responsibility assure you of dependable performance. For more information, call the steel mill representative at your nearest A-C office or write to Allis-Chalmers, Milwaukee 1, Wisconsin.

A-3454



These two Allis-Chalmers 7500 kw condensing steam turbine generator units have been meeting the heavy power demand of the continuous hot trip mill at Granite City Steel Company for nearly 15 years.



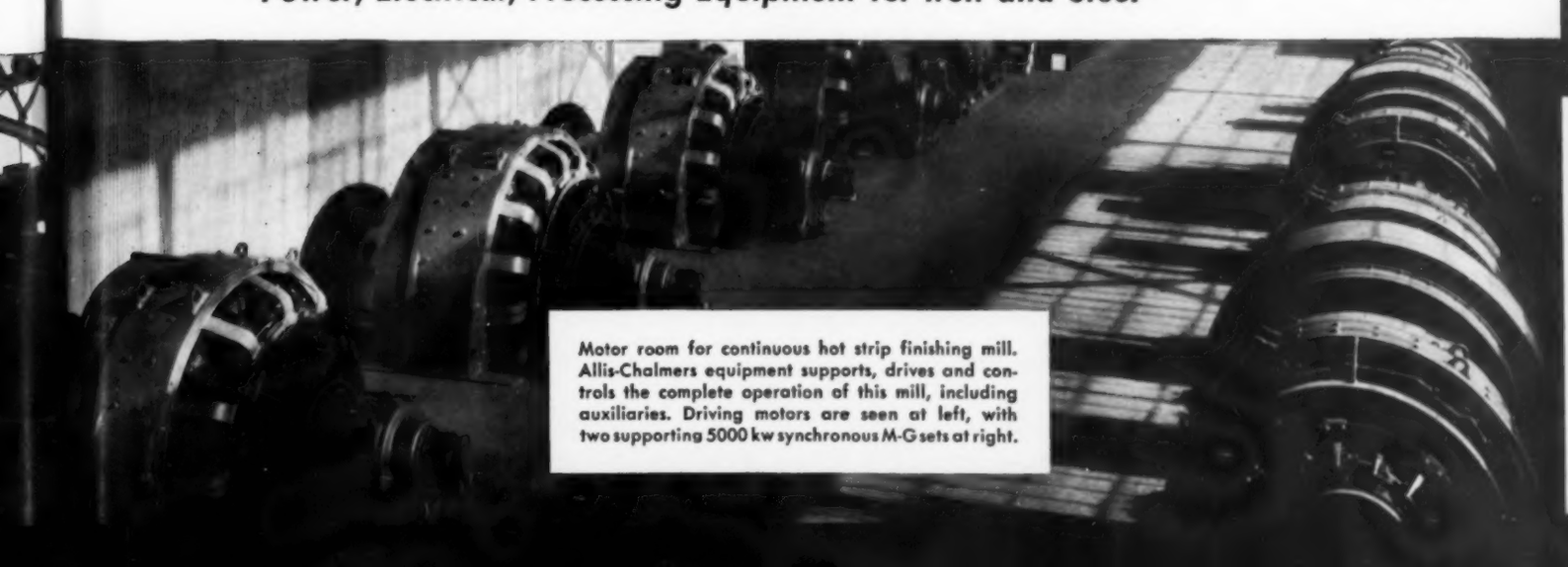
At left above are the 8000 sq. ft. surface condenser, 11,300 gpm circulating water pump, and 150 hp induction motor — all Allis-Chalmers — serving one of the two 7500 kw steam turbines for the hot mill.

Regulex is an Allis-Chalmers trademark.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

Power, Electrical, Processing Equipment for Iron and Steel



Motor room for continuous hot strip finishing mill. Allis-Chalmers equipment supports, drives and controls the complete operation of this mill, including auxiliaries. Driving motors are seen at left, with two supporting 5000 kw synchronous M-G sets at right.

Holds world's 24-hour tonnage record for mills of its type

with help of TIMKEN® bearings!

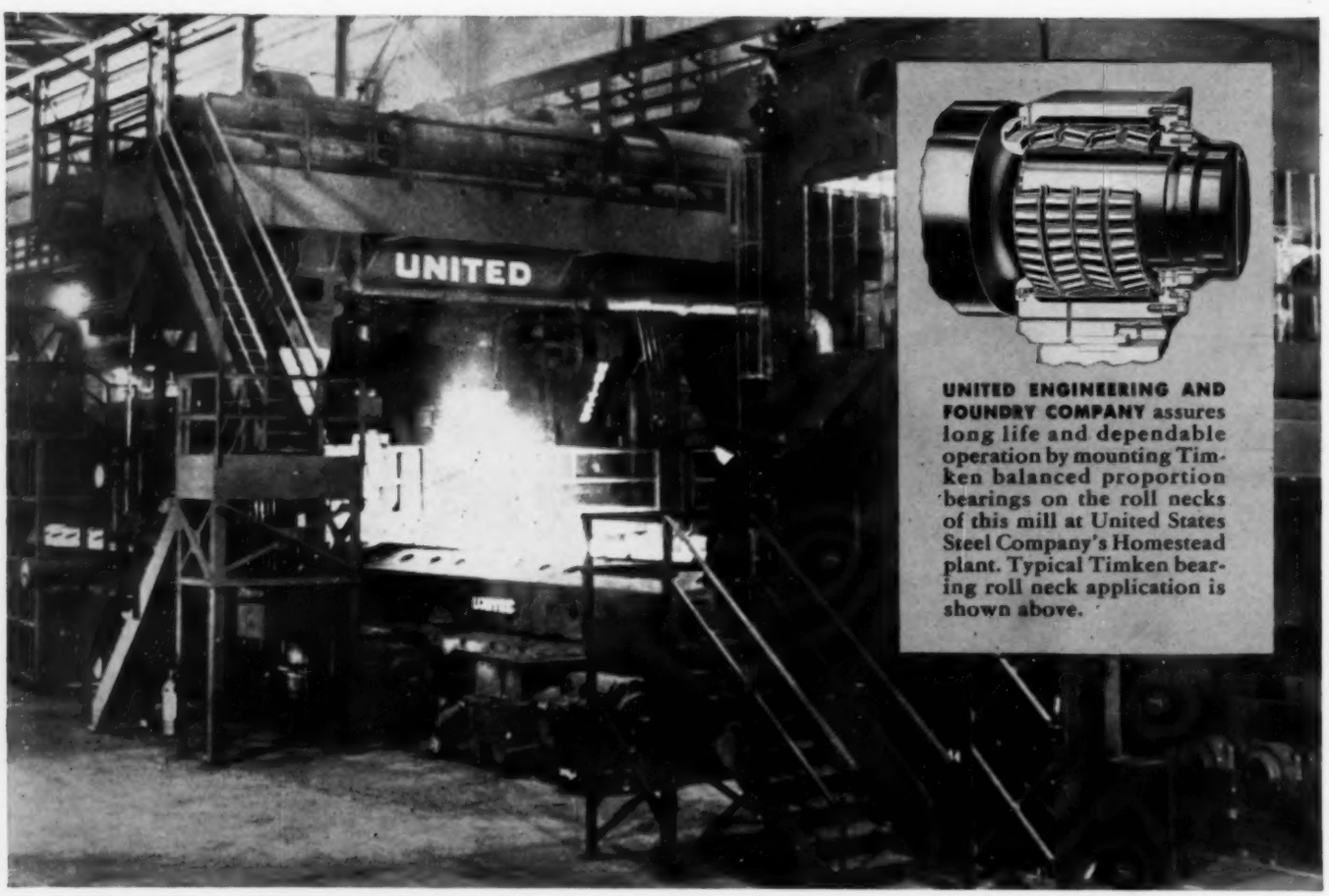
THIS slabbing mill at United States Steel Company's Homestead plant has rolled 11,153 net ingot tons in 24 hours—an unsurpassed record for mills of its type. Timken® bearings on the roll necks have averaged over 2½ million tons. And they're good for many more years.

Lubrication costs of this mill are extremely low, compared to similar mills using other types of bearings. It's further evidence that Timken bearings give long years of economical operation with minimum time-out for maintenance.

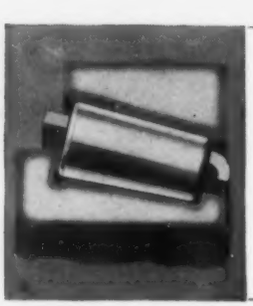
The balanced proportion design of Timken bearings provides a maximum amount of capacity in a given space. Load ratings are increased up to 40%, roll neck strength 50 to 60%. Timken bearings give you greater mill rigidity, permit larger diameter roll necks. No complicated lubrication systems are necessary. And no special thrust bearings are needed, for Timken bearings take radial and thrust loads in any combination.

No other bearing can give you all the advantages you get with Timken bearings. Be sure to specify them for your roll necks. For full information, consult our roll neck bearing specialists. Write The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.



UNITED ENGINEERING AND FOUNDRY COMPANY assures long life and dependable operation by mounting Timken balanced proportion bearings on the roll necks of this mill at United States Steel Company's Homestead plant. Typical Timken bearing roll neck application is shown above.



GREATER LOAD AREA

Because the load is carried on the *line* of contact between rollers and races, Timken bearings carry greater loads, hold shafts in line, wear longer.

The Timken Roller Bearing Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

TIMKEN

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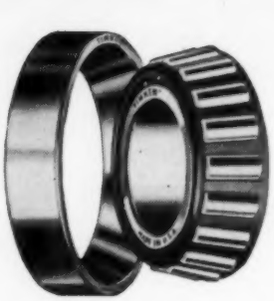
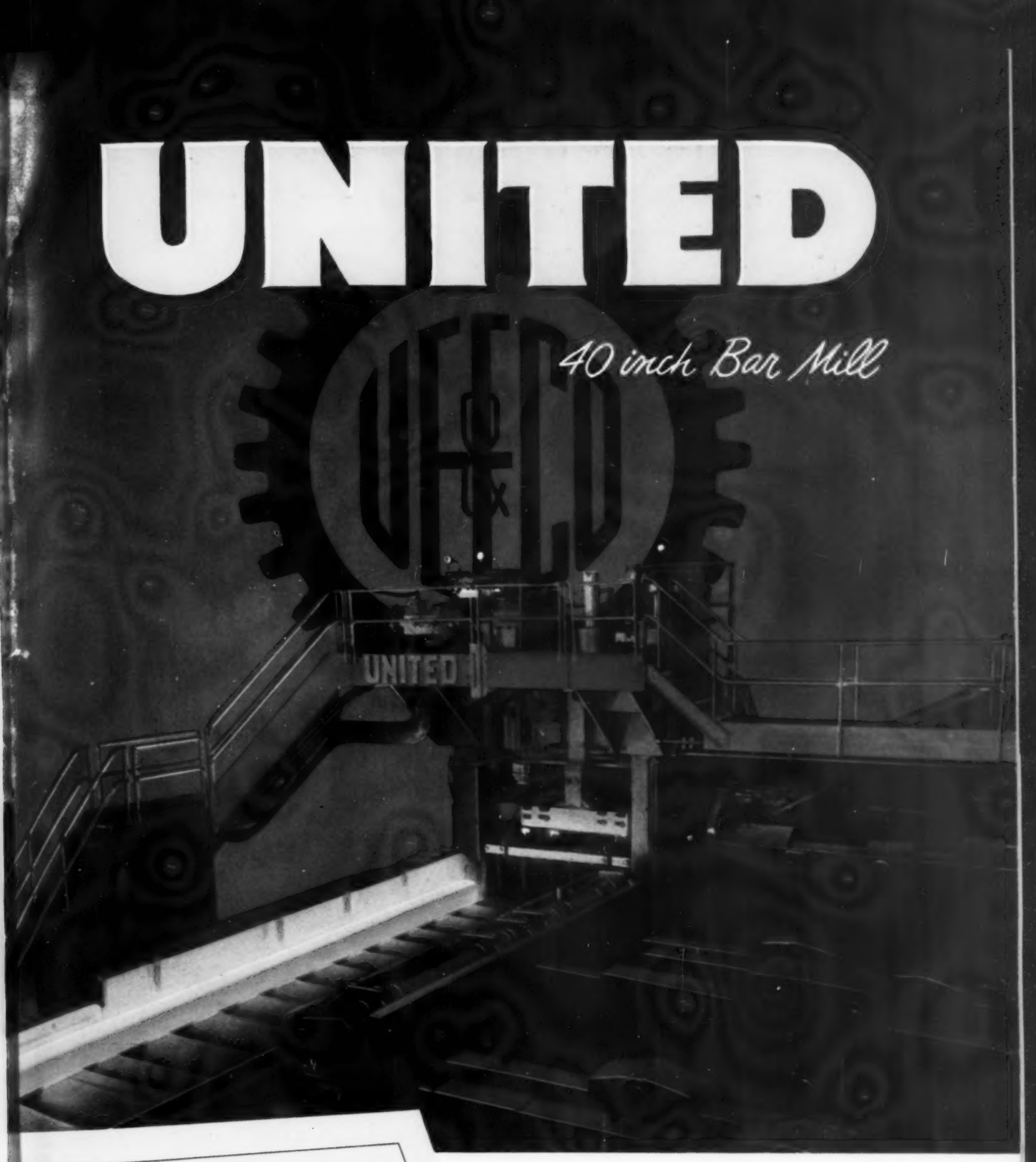
TAPERED ROLLER BEARINGS





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COMPANY
Pittsburgh, Pennsylvania

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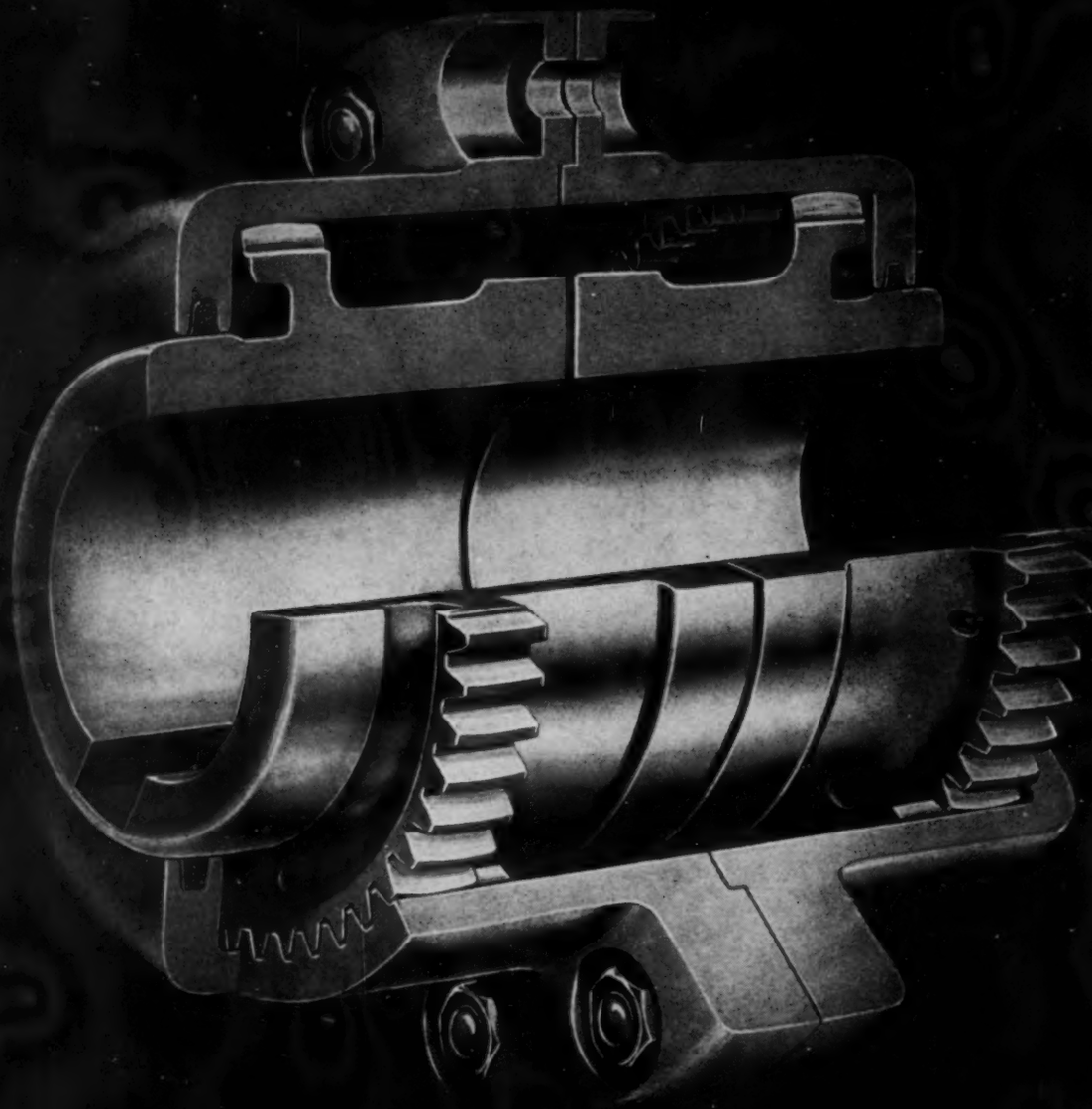

A COPY OF CATALOG GIVING FULL DESCRIPTION AND ENGINEERING DATA SENT UPON REQUEST.

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POOLE FOUNDRY & MACHINE COMPANY

WOODBERRY, BALTIMORE, MD.

Reclaiming of burned-out slag pots by Thermit Welding saves one major steel producer $35,000 a year.

Here, and at other plants slag pots are repaired speedily by means of Thermit, saving time and work over other methods. In addition, because they match closely the composition and characteristics of the base metal, Thermit welds stand up under the severe service conditions of alternate heating and cooling to which slag pots are subject. Re-welding at the same location is unknown . . . much longer life for reclaimed pots is assured.

Many steel mill maintenance jobs are done more easily, more quickly and at lower cost with Thermit. Investigate! Write for complete information.

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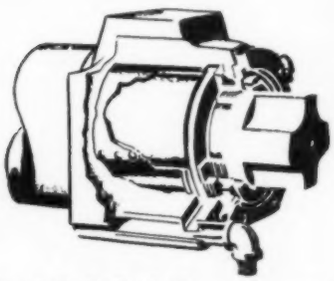
Quick Reference Guide

to improved lubrication and lower maintenance costs for rolling mill equipment



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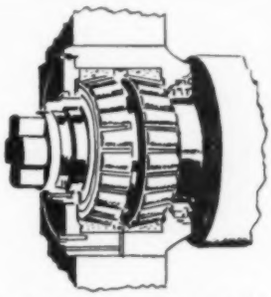

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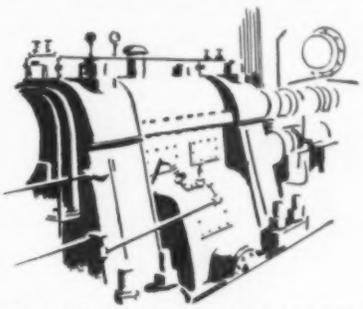
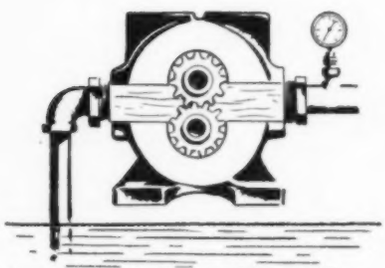


GULF E. P. LUBRICANTS — better protection for heavily loaded enclosed gears and pinions—good water separating characteristics.



GULF HARMONY OIL Prevents rust and sludge in hydraulic systems. Good water separating characteristics.

GULF PRECISION GREASE — For better lubrication of ball and roller bearings in steel mill equipment.

GULF LUBRICATION ENGINEERS can help you improve your lubrication practice, reduce your maintenance costs.

It will pay you to investigate their application in your mill . . . Call in a Gulf Lubrication Engineer today! Also ask for a copy of the booklet "Gulf Periodic Consultation Service," which tells about Gulf's advanced cooperative service for users of petroleum products.

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Life-Line motor
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Dependability...

wrapped in explosion-proof construction

Here's an explosion-proof team that has the inherent dependability so important to today's mining operations. There's no time to pamper motors and controls. After installation, they have to stand on their own feet. These Life-Line motors and Minestarters have been establishing such a record for many years. They're built to meet Bureau of Mines standards.

Look at this Life-Line SK d-c motor. Its pre-lubricated double-sealed bearings need no lubrication. The bearings are sealed, too—no chance for grit or dirt to enter and cause bearing wear. The heavy all-steel frame and feet add extra mechanical strength—stand up to the daily abuses encountered in many mine locations.

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Its design provides continuous operation. Magnetic blowouts on the magnetic contactor quickly confine, divide and extinguish the arc—minimize burnout of contact tips. Contacts operate with a rolling action—confine arcing to the tips of the contacts. Thermal overload relay lags on short high-current peak during starting—acts instantaneously when overload can cause damage.

Talk it over with your Westinghouse representative. Ask him for a specific recommendation to meet your problem. Or, write direct to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21650

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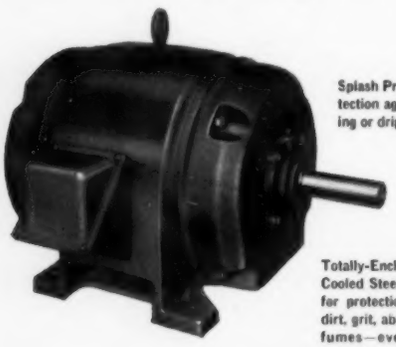
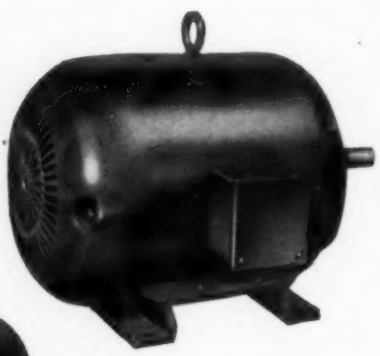
GUARD PRODUCTION WITH Wagner Protected Motors

Do you use motors in locations where dirt, filings, moisture, splashing liquids, explosive gases, acid fumes, or other motor hazards prevail? If you do —no matter how severe the operating condition—Wagner can furnish the *right* motor for your purpose, adequately protected for specialized requirements.

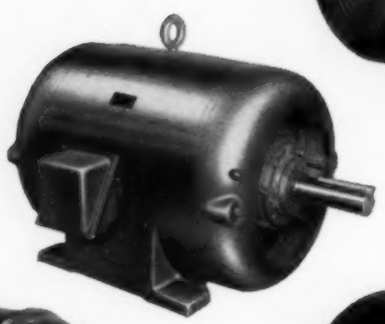
Wagner protected type motors are known for completely dependable operation in their specific applications. They are backed by sixty years of motor building experience. Five protected-type Wagner Motors are shown below. Bulletin MU-185 gives full information . . . write for your copy.



Splash Proof—for protection against splashing or dripping liquids.



Totally-Enclosed Fan-Cooled Steel Frame—for protection against dirt, grit, abrasives, or fumes—even in abnormal quantities.



Totally-Enclosed Fan-Cooled Cast Iron Frame—for protection against corrosion from fumes or moisture.

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In any cable, tiny and hidden imperfections may not show up at ordinarily-specified test voltages. In actual service, such imperfections can be most treacherous since at normal operating voltage they may not result in dielectric breakdown for several years. Only by the use of super-voltages, both a-c and d-c, are such concealed defects disclosed.

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De Laval Mill Lubrication Systems are designed for all sizes of mills. For large mills, the lubrication systems are custom-designed. For smaller mills, De Laval offers the Unilube System which is a self-contained unit with circulating capacities of 1 to 40 g.p.m.

In both cases, the De Laval Lubrication Systems are completely engineered. They all include the proper selection of pipe size, the correct metering of the lubricant, the proper control of temperature, and purification of the lubricating oil.

Oil purification is accomplished by means of the De Laval Centrifugal Oil Purifier, which continuously removes contamination and water. By keeping the lubricating oil clean and dry, bearing life is prolonged and maintenance costs are minimized.

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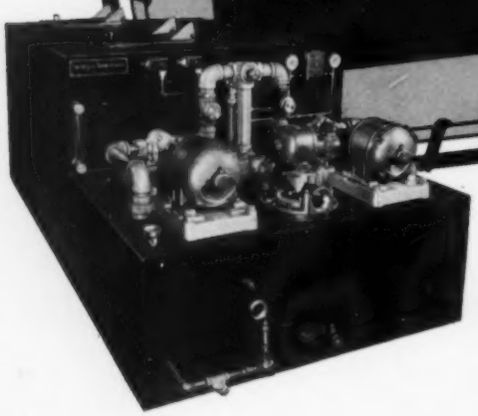

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New production records recently reported by leading European steel plants can be directly traced to many Bliss installations. That's because Bliss engineers have long recognized that truly efficient mill production can only be achieved by maximum use of properly designed metal-handling machinery.

During the past year alone, Bliss Rolling Mills and Accessories—2-high, 4-high, 6-high—levelers, coilers, reels, rewinders, slitters, shears—have revitalized mill lines in Italy, Sweden, Belgium and Switzerland by speeding metal transfer to and from hot and cold rolling mills.

You, too, can step up your plant efficiency by looking to Bliss for rolling mills and accessories. Here's a good way to start. **Write for your copy of the new Bliss 52-page brochure, including the complete range of rolling mill machinery and valuable engineering tables you will want for ready reference.**

E. W. BLISS COMPANY
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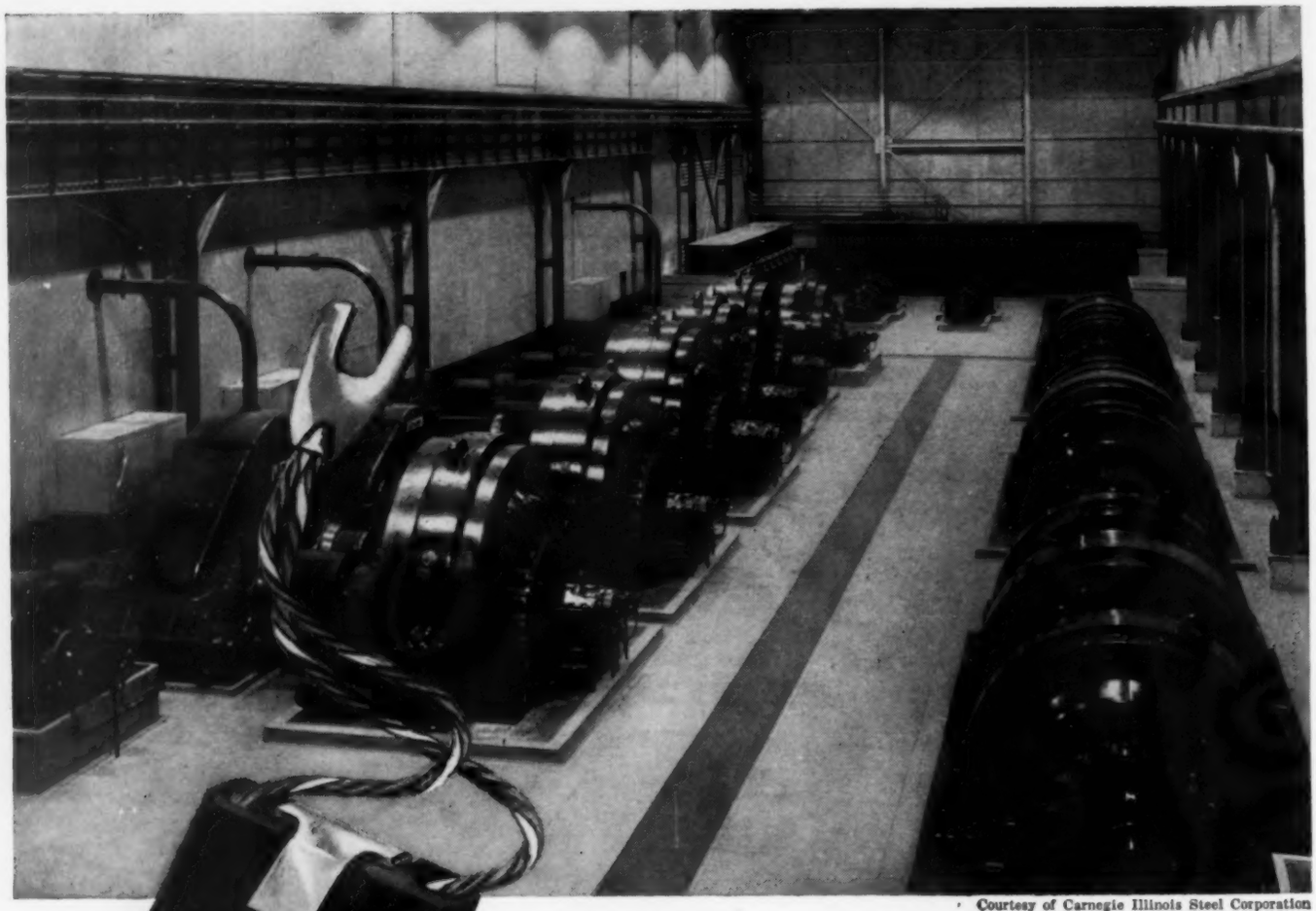

Courtesy of Carnegie Illinois Steel Corporation

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The NATIONAL standardized brush for main-drive motors

Main-drive motors and generators are the most important machines in the mill. If one of them fails, production stops dead. Tons of steel may be held up. It doesn't pay to take chances with the brushes on this vital equipment.

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- Complete dependability, proved in service for many years
- Closely controlled commutation factor
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STANDARDIZED BRUSHES FOR MAIN-DRIVE MOTORS AND GENERATORS

NC NUMBER	SPECIFICATIONS	APPLICATIONS
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NC 16-5603	2½ x 1¾ x ½ Grade SA-35	For Westinghouse Tandem Holders
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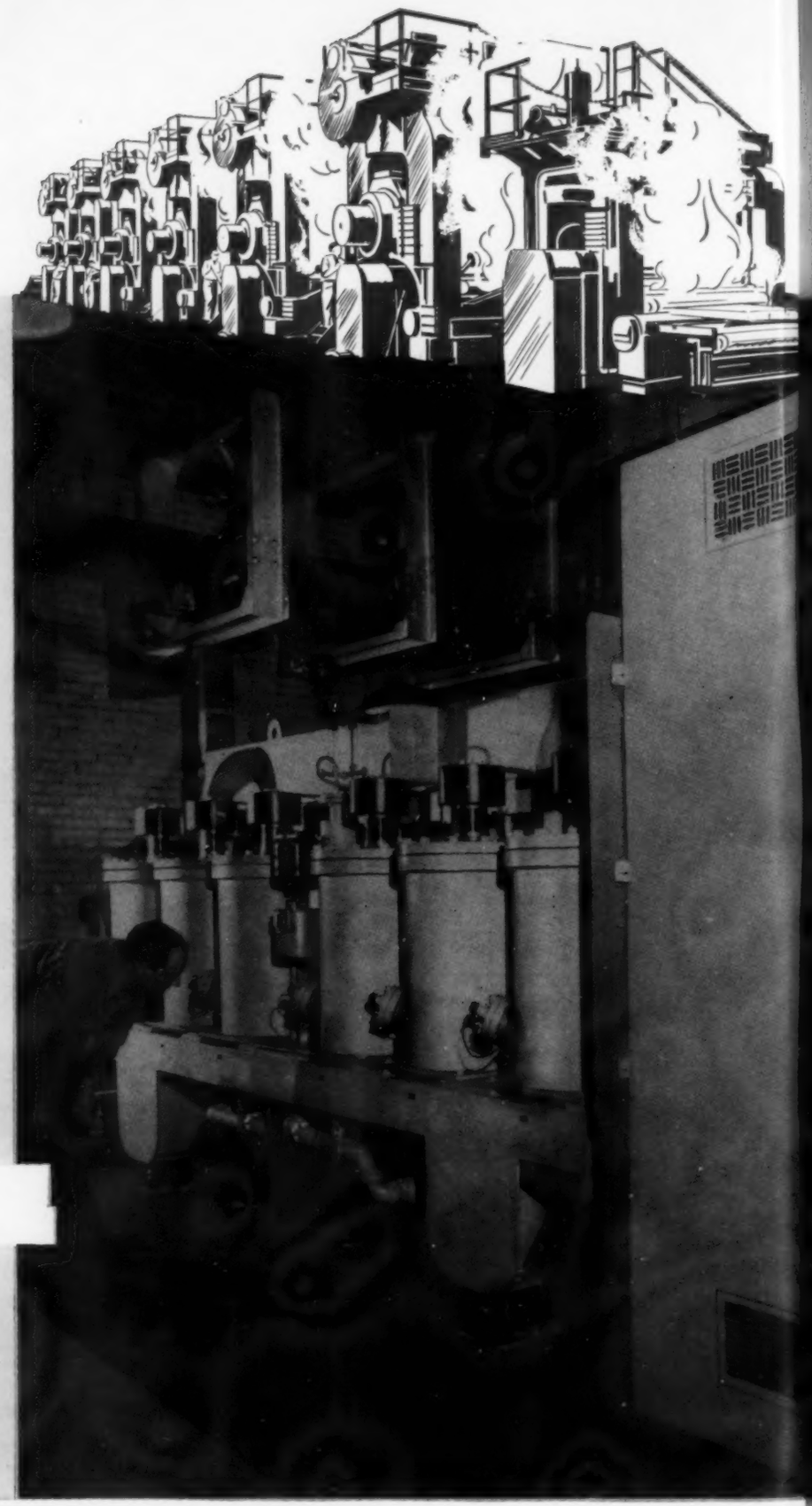
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.—*manufacturers of* SKF *and* HESS-BRIGHT *bearings.*



They did...

This Ignitron unit supplies a hot-strip mill in a big New York plant. When the mill was being planned, the company realized the advantages of the best power supply—in reduced costs, lower maintenance, and increased production.

what...

They called in Westinghouse early in their plans to get the benefit of Westinghouse experience in similar installations.

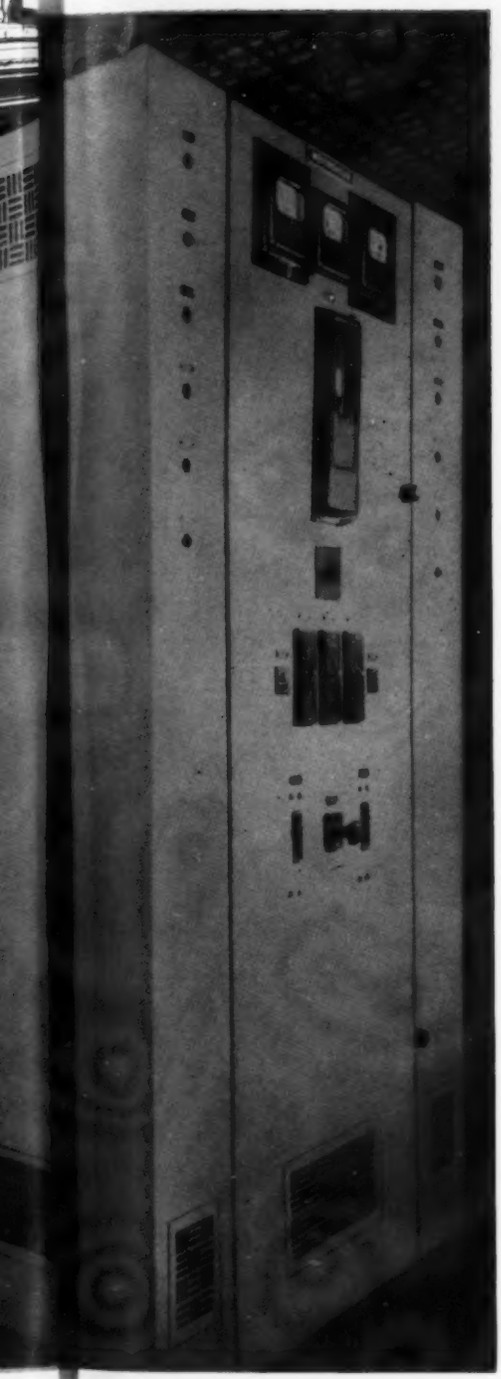
you can do...

Do what scores of other steel firms are doing. Have Westinghouse work with your engineers and machinery builders in applying equipment to your plant.

to produce more

Whether it's a new power system, a mill drive, better servicing, or a piece of electrical equipment to do a tough job ... Westinghouse has the answer.

Here's a new idea for your next rolling mill drive



Westinghouse Ignitrons are a new and proven power source for certain main mill drives. They cut the installed cost, the maintenance cost, and the power bills—for hot strip mills, merchant, rod and bar mills, seamless tube mills. Here's the record of the Ignitrons now in service.

Westinghouse Ignitrons cut costs, save power

Ignitrons cost less than M-G sets, need no special foundations, ventilation or alignment. But the big savings come after they're installed. Ignitrons are considerably more efficient than M-G sets. In the usual hot-strip mill the power saving is 600 kw. This amounts to $36,000 per year on a three-shift operation, figuring power at 1 cent per kwhr.

Excellent operating characteristics

From an operating standpoint, Ignitrons have thoroughly proven their practicality in this service. For starting, the d-c output voltage is reduced by "phase control". Turning a switch brings the mill to full operating speed. The Ignitrons normally supply all the power to the mill, but in two installations they operate in parallel with M-G sets.

Pumped tubes have longest life

Maintenance on Westinghouse Ignitrons averages two-thirds that of M-G sets. A big factor here is the long life of pumped Ignitron tubes. Gases are instantly sucked out by the vacuum system; they can't shorten tube life or necessitate factory overhauls. The vacuum system itself needs about three hours of maintenance once a year.

Call Westinghouse early on EVERY job

For more information about Ignitron rectifiers get in touch with your Westinghouse representative. And be sure to call in Westinghouse early whenever you're planning *any* new mill capacity. Westinghouse Electric Corporation, Box 868, Pittsburgh 30, Pa.

J-94881

YOU CAN BE SURE.. IF IT'S
Westinghouse

EQUIPMENT FOR
STEEL PRODUCTION

1951

You can make important savings in fuel by taking advantage of the quick heating characteristics of J-M Insulating Fire Brick. These light-weight brick permit a quicker rise to proper operating temperature in the furnace because of their low heat storage capacity, and low thermal conductivity. Where furnaces are being intermittently operated these are two especially important characteristics.

These same insulating materials can also be obtained in large size units called Johns-Manville Insulating *Fireblok*. This product has many advantages over the smaller size fire brick for certain types of jobs . . . from both a construction and stability standpoint. The Fireblok units can be quickly applied because they are easy to cut and fit. Fireblok insulations provide additional heat savings because they reduce the number of joints, and require less mortar for bonding.

It will pay you to let a Johns-Manville insulation engineer explain the many ways in which you can save by using these insulations in your furnaces. Just write for further information to Johns-Manville, Box 290, New York 16, N. Y.

JM

	JM-1620	JM-20	JM-23	JM-26	JM-28	JM-3000
Densities, lb per cu ft.	29	35	42	48	58	63-67
Transverse Strengths, psi.	60	80	120	125	120	200
Cold Crushing Strengths, psi.	70	115	170	190	150	400
Linear Shrinkage†, percent.	0.0 at 2000 F	0.0 at 2000 F	0.3 at 2300 F	1.0 at 2600 F	4.0 at 2800 F	0.8 at 3000 F
Reversible Thermal Expansion, percent.	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2,000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F	0.5—0.6 at 2000 F
Conductivity* at Mean Temperatures						
500 F.	0.77	0.97	1.51	1.92	2.00	3.10
1000 F.	1.02	1.22	1.91	2.22	2.50	3.20
1500 F.	1.27	1.47	2.31	2.52	3.00	3.35
2000 F.	—	1.72	2.70	2.82	3.50	3.60
Recommended Service						
Back up.	2000 F	2000 F	2300 F	2600 F	2800 F	3000 F
Exposed.	1600 F	2000 F	2300 F	2600 F	2800 F	3000 F

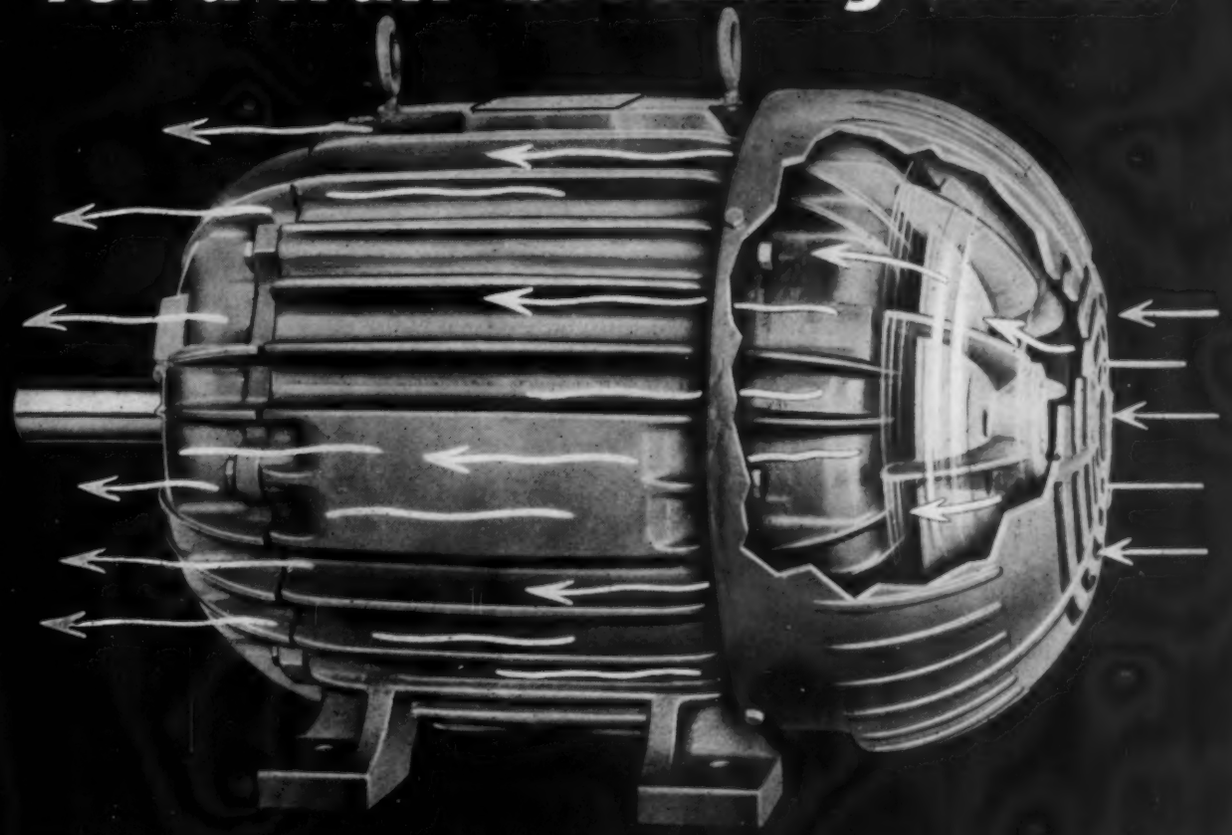
†24-hr. simulative service panel test for JM-3000; 24-hr. soaking period for other brick.

*Conductivity is expressed in Btu in. per sq ft per F per hour of the designated mean temperatures.

Note: Above tests are in accordance with A.S.T.M. tentative standards.

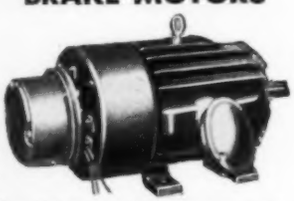
Johns-Manville *first in* **INSULATIONS**

TENTH ANNIVERSARY
for a trail-breaking motor



THE ELLIOTT CROCKER-WHEELER *Sealedpower* MOTOR

SEALEDPOWER BRAKE MOTORS



The C-W Sealedpower motor is available equipped with the newly designed C-W Brake, providing increased brake capacity without increased bulk.

The Elliott C-W Sealedpower motor is available also in explosion-proof construction. Bulletin SL-300-5 covers this type. Copy on request.

Crocker-Wheeler motors range from 1 to 200 hp. Larger Elliott motors and generators are built by the Ridgway Division in Ridgway, Pa.

TEN YEARS AGO the C-W "Sealedpower" motor, with its unique cooling and self-cleaning system, made its bow to American industry. Its immediate and continued popularity has put thousands into successful service.

Completely enclosed, there's no way for dirt, dust, moisture or fumes to get in. But there's an easy out for heat—by way of the 150% increased radiating surface of the many radial fins, plus the fan-driven air blast directed along and around the fins and frame. It cleans itself, too—the air blast gives dirt and dust the quick brush-off.

WAY AHEAD OF ITS TIME ten years ago, the C-W Sealedpower Motor with further refinements is still ahead, and is the ideal motor for any service within its capacity range. Write today for Sealedpower Bulletin. Address your request to Elliott Co., Dept. IS, Jeannette, Pa.

ELLIOTT COMPANY-*Crocker-Wheeler Division, Ampere, N. J.*

BRANCH OFFICES AND REPRESENTATIVES IN PRINCIPAL CITIES. CW-27

ELLIOTT *Approved* SERVICE SHOPS COVER THE COUNTRY.

GENERAL OFFICES & MAIN PLANT—JEANNETTE, PA.

You're a step ahead with **ELLIOTT**

Price: $.00029 Per Rolled Ton!

How National Bearing Division helps its customers lick costly maintenance problems

If there's one thing tougher than rolling mill service, it's the bearing you see above. This bearing was completely designed—from the inside out—by National Bearing Division and installed on a trial basis by one of the country's largest steel producers.

Result? Where the service life of bearings previously used averaged just 13 weeks, this bearing ran exactly 16 months and 4 days . . . rolling 1,315,000 tons! Maintenance expenses—including costs of replacement and down-time—were cut right to the bone.

This record-breaking performance was made possible through a special design by National Bearing Division . . . a design involving alloy, bore, grease grooves, babbitt pockets and machining procedure. And, performance of these bearings is so consistently outstanding that the same mill now standardizes on their use.

We're proud of examples like this—because they show how effectively our facilities for Alloy Research and Engineering—combined with 75 years of practical application experience—make money-saving solutions to problems on . . .

Non-Ferrous Bearings and Castings—
As-Cast or Machined

Bronze Bars—
As-Cast or Machined;
Cored, Solid, Hexagon

Babbitt Metals—
For every type of bearing service

AMERICAN **Brake Shoe** COMPANY

NATIONAL BEARING DIVISION

4936 Manchester Avenue • St. Louis 10, Mo.

PLANTS IN: ST LOUIS, MO • MEADVILLE, PA. • NILES, OHIO • PORTSMOUTH, VA. • ST. PAUL, MINN. • CHICAGO, ILL.

Courtesy Kaiser Steel Corporation

Production-Records SMASHED With Open Hearths by LOFTUS

FROM FIRST HEAT TO HEAT TREAT, LOFTUS BUILDS 'EM BETTER

Open Hearth operators at No. 7 Furnace of the Kaiser Steel Corporation plant established a new shop record by turning out over 18,000 tons of ingot steel in the month of May.

All of the eight 200-ton Basic Open Hearths erected by Loftus are averaging 23 plus net tons per operating hour and giving

LOWER FUEL CONSUMPTION
MORE TONS PER HOUR
MORE TONS PER MONTH

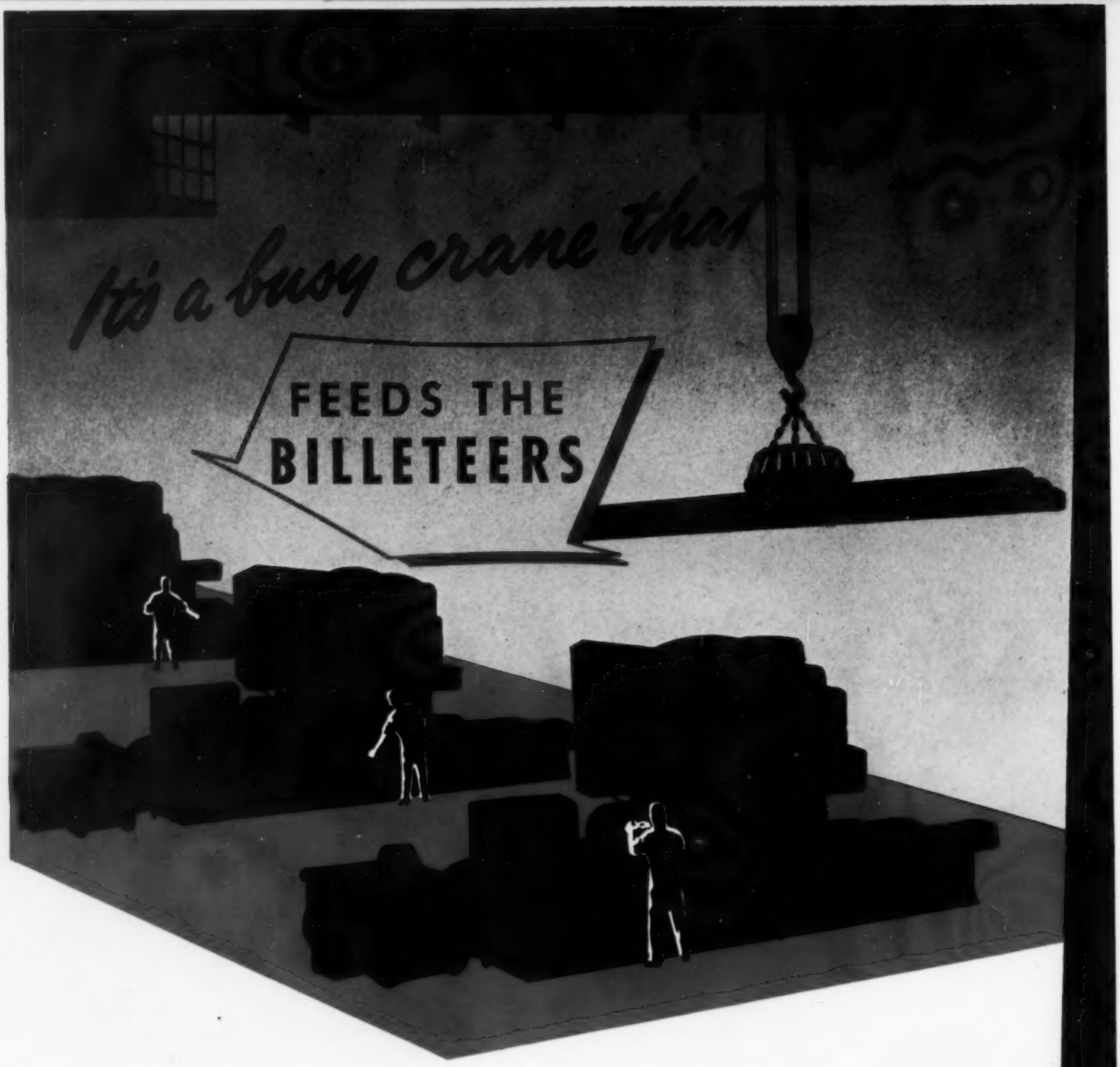
Loftus-designed and constructed Open Hearths assure Lower Fuel Consumption, and greater production. That's why we say "Loftus Builds 'Em Better."

Turn Your Scrap In—Help Turn More Steel Out

LOFTUS ENGINEERING Corporation

610 SMITHFIELD ST. PITTSBURGH, PA.

Designers and Builders of INDUSTRIAL FURNACES



Busy is scarcely the word for steel plants and their cranes these days. They're being pushed to extra capacity! But regardless of demands, the Bonnot Billeteer produces to meet any and every emergency. For instance:

When **SPEED** is essential, actual tests on SAE 4150 steel show the Billeteer chips 49 times faster than hand chippers.

When **SAFETY** is considered, "Billeteering" records show as many as 490,000 manhours without a disabling accident.

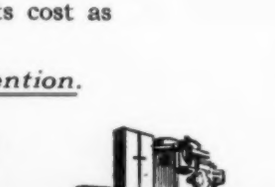
When **MANPOWER** is vital, Billeteers reduce manpower turnover — increase individual productivity.

When **COSTS** must be reduced, user records prove the Billeteer cuts cost as much as 50–60%.

Your Billet-Conditioning Problems Will Get Immediate Attention.

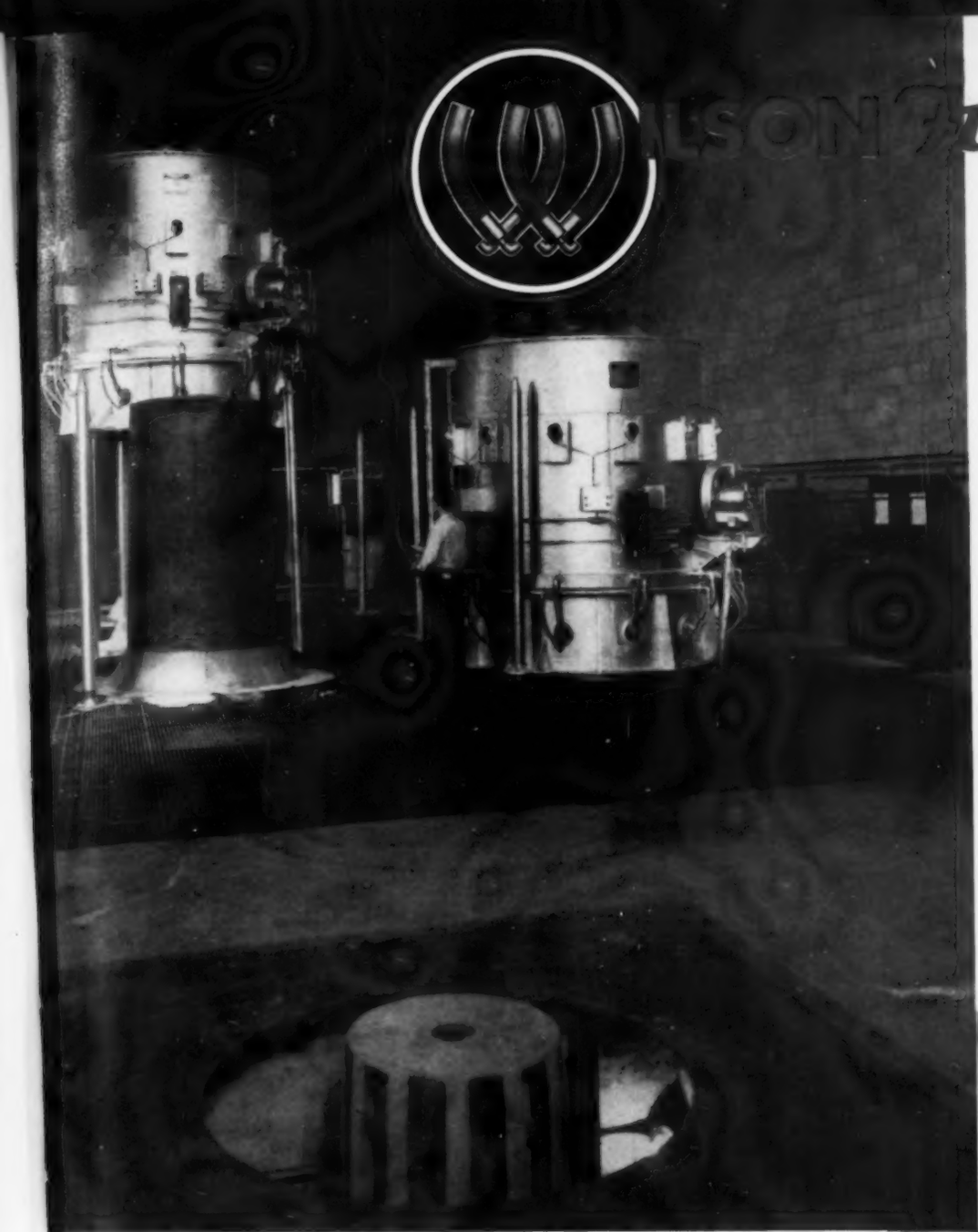
Engineered for Improved Production

The Bonnot Co.
STEEL EQUIPMENT DIVISION
CANTON 2, OHIO

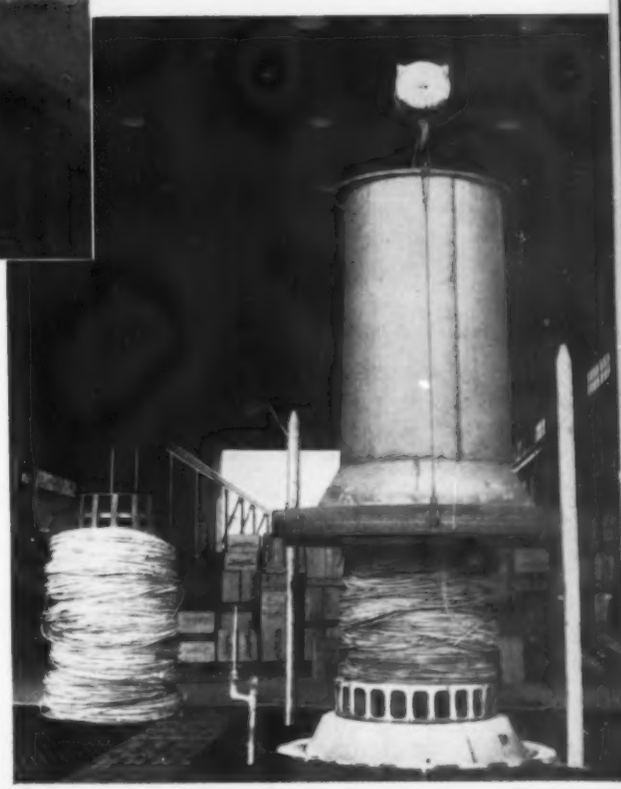


THE BILLETEER

ALSO MANUFACTURERS OF SAWING • CRUSHING • PULVERIZING & MIXING EQUIPMENT
BILLET INSPECTION TABLES • DUST PUG MILLS • SINTER PLANT PUG MILLS



Furnaces for ROD AND WIRE COIL SPHEROIDIZING



Wilson Furnaces like these are in use at such plants as Lamson & Sessions Co., National Screw & Mfg. Co., and 3 plants of Russell, Burdsall, & Ward Bolt & Nut Co., for converting available rod sizes and analyses to useable sizes and physical properties for vital cold heading operations. There are other installations and most are equipped with atmosphere generating equipment to control decarburization.

Lee Wilson ENGINEERING Co., Inc.

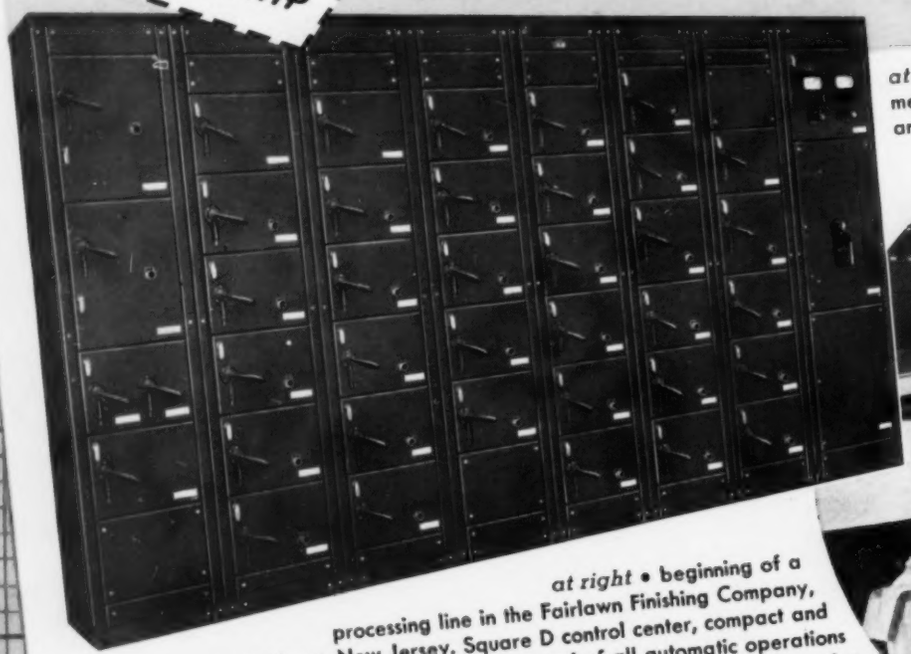
20005 WEST LAKE ROAD • CLEVELAND, OHIO

Telephone ED-1-6600

BELL TYPE FURNACES ★ RADIANT TUBE HEATING ★ ANNEALING PROCESSES

SQUARE D "PLUG-IN" Control Centers

DESIGN LEADERSHIP



at left • Control center with main breaker, metering panel, 33 combination starters and 6 branch breakers.

at right • beginning of a processing line in the Fairlawn Finishing Company, Fairlawn, New Jersey. Square D control center, compact and out of the way, provides control of all automatic operations in applying water-repellent finish on nylon.

for ECONOMY · SAFETY · FLEXIBILITY

ECONOMY in installation because factory assembly has done most of the work of mounting and wiring individual motor starters. For easy wiring, large vertical and horizontal gutters are front accessible without removing units. Economy of space because standard 20"W x 20"D x 90"H sections accommodate up to six combination motor starters.

SAFETY because bus structure is rigidly supported on porcelain insulators and is designed to withstand short circuits up to 25,000 amperes. Safety because dead front handle mechanism always indicates true position of circuit breaker or switch and can be locked off with one to four padlocks.

FLEXIBILITY because plug-in units may be removed, added or exchanged at will. Both fusible switch and circuit breaker types are available. Flexible because standardized sections and units are always re-usable after plant conversion.

Your nearby Square D Field Engineer will give you the complete story . . . or write for BULLETIN 8938. Address **Square D Company, 4041 North Richards Street, Milwaukee 12, Wisconsin.**

ASK YOUR ELECTRICAL DISTRIBUTOR FOR SQUARE D PRODUCTS

SQUARE D COMPANY

DETROIT • MILWAUKEE • LOS ANGELES

SQUARE D COMPANY CANADA LTD., TORONTO • SQUARE D de MEXICO, S.A., MEXICO CITY, D.F.

30% GREATER CONTACT TRAVEL

With NEW KEYSTONE LMI PONY SIZE COLLECTORS

New advantages . . . new economies . . . are now offered with the Keystone LMI Pony Size Collectors! These new collectors are designed for continuous, efficient performance despite severe operating conditions. Outstanding advantages include: improved contact shoe, readily reversible, provides 30% greater contact travel, adds 300% more wearing thickness on each side, lower in overall height.

Solderless throughout, shunt connectors have non-loosening electrical connections. Copper plating on machined surface insures better electrical contact where shunt is connected and prevents corrosion. Maintenance simplified. Only one tool required.

The new Keystone LMI Pony Size Collectors last longer . . . help you reduce inventories and give improved service. For complete information ask for Bulletin 681B. Write today.

OUTSTANDING FEATURES

- 30% greater contact travel
- Improved contact shoe
- Efficient current transfer
- Solderless shunt connectors
- Rapid contact reversal
- Compensating terminal
- Lower overall height
- Collector reversible
- Easy to maintain

ELECTRIC SERVICE MANUFACTURING CO.

PHILADELPHIA 32, PENNA.

MANUFACTURERS OF COMPLETE LINE OF INSULATOR SUPPORTS FOR RAIL AND WIRE CONDUCTORS AND CURRENT COLLECTION DEVICES.

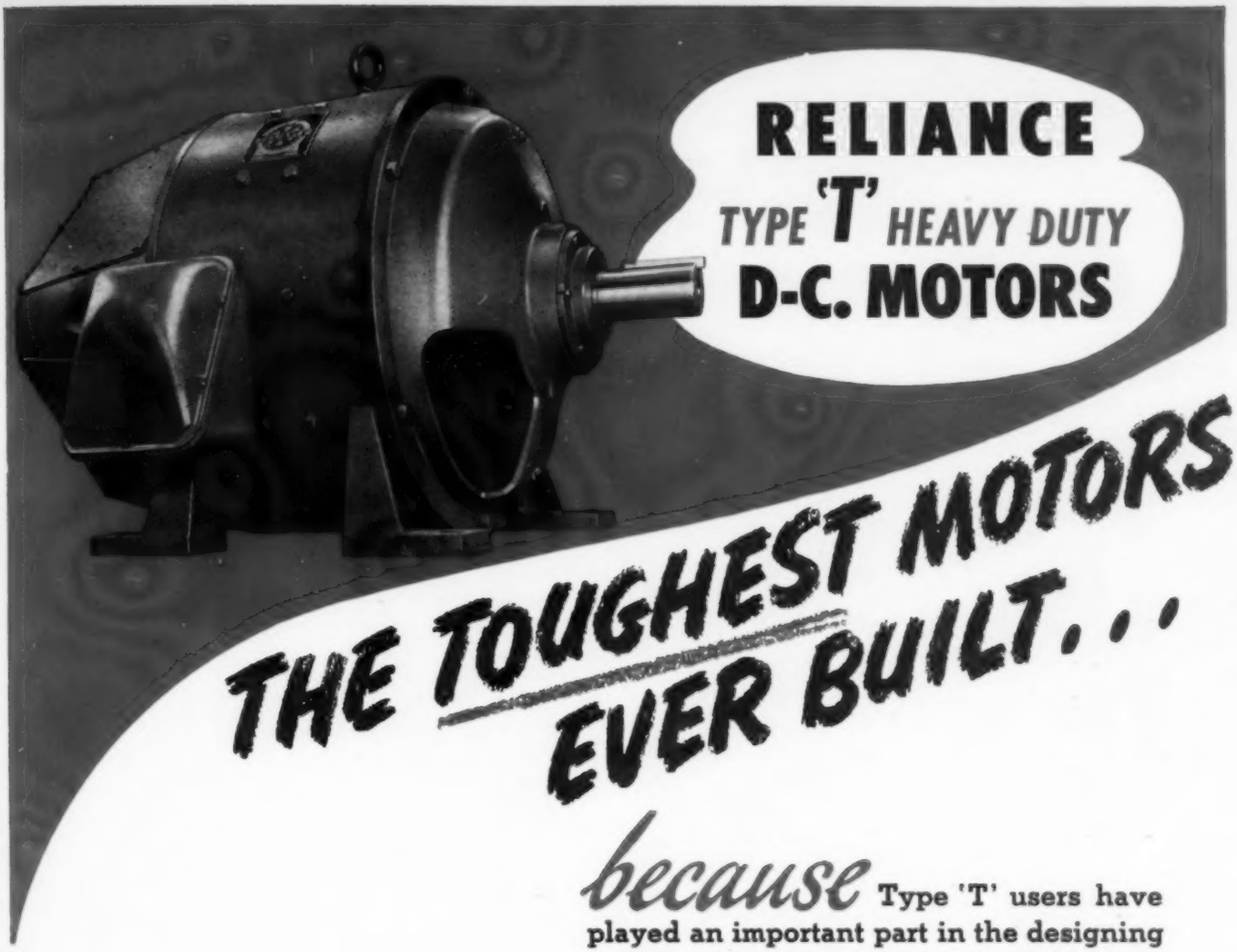
New tighter fit

So positive is the fit between seat and plate on this time-tested Brosius-Westling Goggle Valve, that the unit pressure is comparable to that found on flange gaskets in pressure piping. In addition to this new feature, distortion is eliminated due to heavy construction and separation between barrel and frame... moreover, manual operation is easy and fast even after long periods of idleness. Numbers of these valves are currently contracted for, yet capacity has not been reached and your inquiry is invited.

BROSIUS DIVISION

Salem - Brosius, Inc., Pittsburgh 15, Pa.

Affiliates: Salem Engineering Division, Salem, Ohio;
Salem Engineering Co., Ltd., Milford nr. Derby, England; Salem Engineering (Canada) Ltd., Toronto, Canada



RELIANCE
TYPE 'T' HEAVY DUTY D-C. MOTORS

THE TOUGHEST MOTORS EVER BUILT...

because Type 'T' users have played an important part in the designing and the constant improvement of these motors to meet all of the rugged service conditions encountered today in plants, mills and mines.

Heavy duty, double-taped coils, for example, are impregnated with a wear-resistant polymerizing varnish which assures unsurpassed mechanical protection. For other important construction features, mechanical designs, dimensions and selection data, write for Bulletin C-2001.

Constant and adjustable-speed Type 'T' Heavy Duty D-c. Motors are available from ¾ through 1000 horsepower.

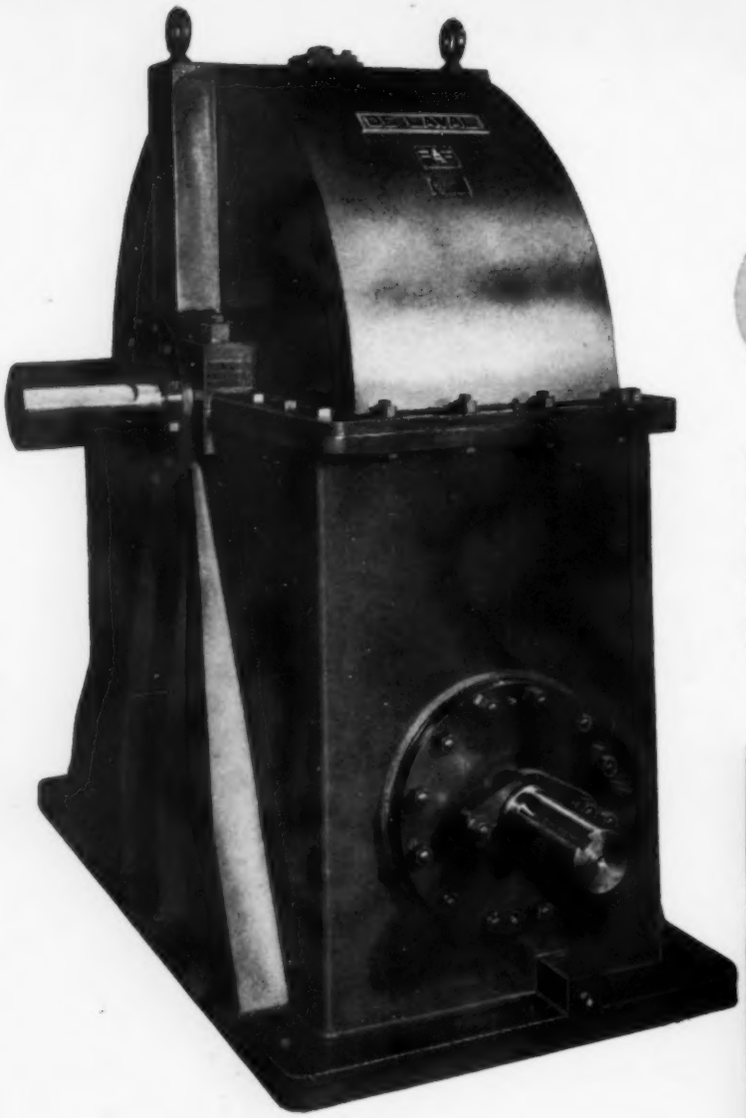
Type 'T' Heavy Duty D-c. Motor Frame with 6-pole field windings

Sales Representatives in Principal Cities

RELIANCE ELECTRIC AND ENGINEERING CO.

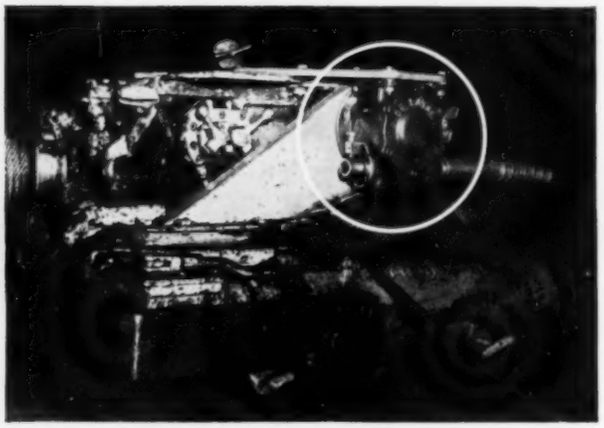
"Motor-Drive is More Than Power" • 1084 Ivanhoe Road, Cleveland 10, Ohio

We build'em all sizes at De Laval



Giant

Take a look at this 30" center distance worm gear speed reducer! As far as we know, it is the *largest* standard enclosed drive unit ever built. It's doing a big job, too, on a large Mesta Machine Co. slabbing mill for a prominent steel company. A twin of this giant is scheduled for a new eastern mill.



Dwarf

Here's one of the smaller De Laval worm gear speed reducers with a 3" center distance. It is being used by the Crichton Company, Johnstown, Pa. for their new coal drilling machine. Big, small or in-between, De Laval heavy duty worm gear reducers are proving profitable investments for scores of machinery manufacturers throughout the country.

FREE

Easy-Selection Manual

Is there a quick way to select the right reducer for your application? Yes, new De Laval Manual G-WBV makes it simple as ABC. It contains complete selection data, hp rating tables and outline drawings . . . all set up in easy-to-use form. Write for your copy today.

50th Anniversary

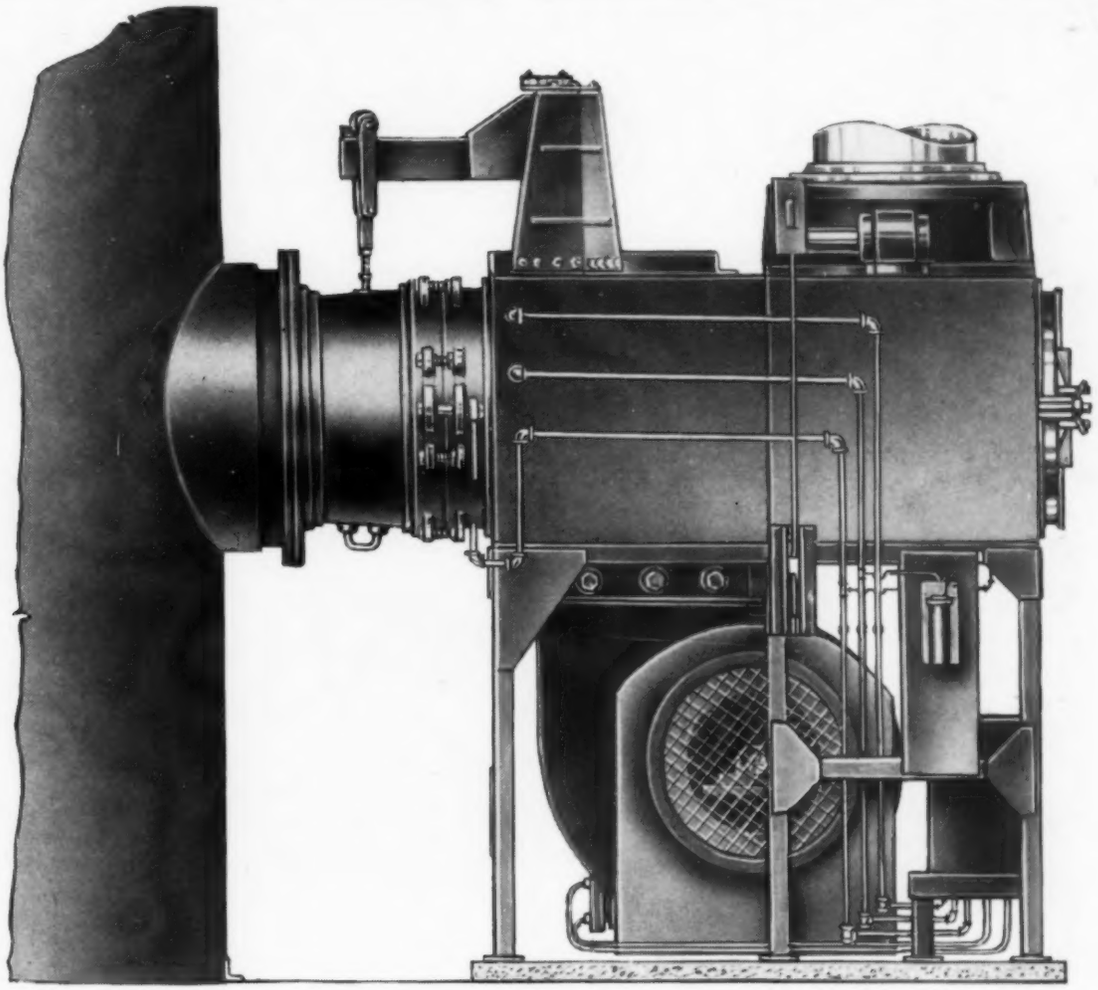
DE LAVAL *Speed Reducers* ***Built to be Built-into a Quality Product***

DE LAVAL STEAM TURBINE COMPANY • TRENTON 2, NEW JERSEY

DL-105

Ideal Combustion Conditions for

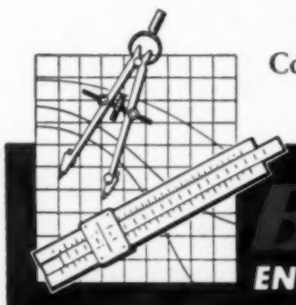
MAXIMUM STOVE CAPACITY!



The **BLOOM-PAULSEN-STEINBART**

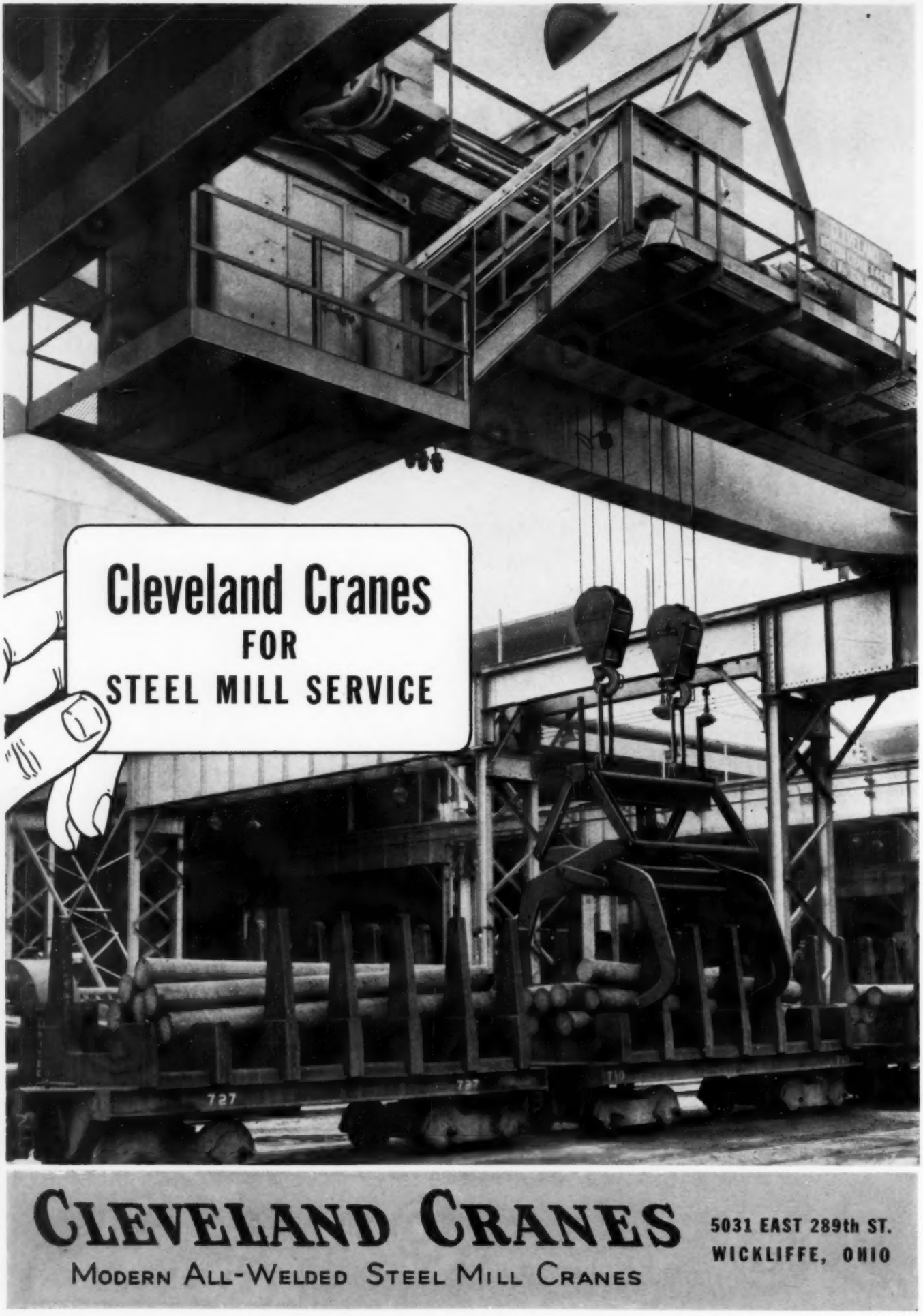
BLAST FURNACE STOVE BURNER

Automatic proportioning of air and gas at the ratio you select provides combustion conditions that assure correct temperature distribution for maximum stove heating capacity. Compact, sturdy construction; easy to operate and flexible.



BLOOM
ENGINEERING CO., INC.
857 W. North Avenue Pittsburgh 33, Pa.

Write for illustrated bulletin giving full details and operating data.



CLEVELAND CRANES

MODERN ALL-WELDED STEEL MILL CRANES

5031 EAST 289th ST.
WICKLIFFE, OHIO

Crops *and* Shorts

WE are growing very weary of government press agentry constantly trying to club us into useless frenzy about what might happen. The net result of all this needless needling seems to be a thorough saturation of many youngsters (and some adults) in a doctrine of defeatism and "what's-the-use." Boys and girls in grammar school have had atomic bombing impressed on them until it has become almost an obsession, resulting in all sorts of irrational ideas and actions. Many boys in high school and college have interrupted their education or have been distracted to a point where it is doing them no good.

In talking to the many European visitors who find their way to our office, one cannot help but be impressed by their outlook upon present conditions and upon the future. With a philosophy tempered perhaps by centuries of turmoil and upheavals, they recognize the gravity of the situation but they worry less — or at least, worry less obviously — about what might happen. There is the feeling that what is to be, will be, and the best thing to do meanwhile is to do the best you can.

If present world conditions are to continue for many years, as many of our government heads say, we must certainly learn to endure them and to go on doing the best we can. And it would help if we got less press agentry, less scolding and more leadership from our government.

▲

THERE'S a great day coming for bachelors and husbands whose wives object to darning. According to a recent announcement, four new synthetic fibres are being used in the manufacture of socks, with glowing reports of increased service. One manufacturer reports that the postman reported 450 miles of wear before the first small hole appeared.

▲

BEFORE long an applicant for a job may be asked to take a lie detector test in addition to the other tests that are becoming a part of hiring routine. Recently a plastic product manufacturer, disturbed by information leaking to a competitor, used lie detector tests to spot four of his key technicians who were in the pay of the competitor.

The placing of men in competitors' plants in order to obtain some particular information used to be fairly common in the steel industry years ago, and may still be practiced in important cases, although the interchange of ideas and information in the industry has improved to a point where such moves are hardly necessary.

A CORRESPONDENT tells us that contentment is something that depends a little on position and a lot on disposition.

▲

IT may sound repetitious, but the iron and steel industry in May met the highest monthly payroll in its history and employed more persons than ever before. According to figures from the American Iron and Steel Institute, the estimated total payroll in May was $249,007,000 and the employment was 667,300 persons. Wage earners worked an average of 41.6 hours a week and were paid an average of $1.942 per hour.

It is also interesting to note that the month of May showed 16,260 separations, or about one in 40, which gives an annual employee turnover of about 30 per cent.

▲

A RECENT newspaper comment: "There is some argument over the origin of civilization. But this is unimportant compared with the question of when it will resume operations again."

We're inclined to voice some interest also in its destination. As Hy Sheridan says: "We philosophers are disturbed not because we think that civilization is going to hell but because it now looks like such a short trip."

▲

UNITED States Steel Co. has ordered a carbon lining that will extend up into the shaft 40 ft above the mantle for one of its Gary blast furnaces. The lining will approximate 2,000,000 lb of carbon.

▲

IT isn't really true that cold cash is so called because few of us can keep it long enough to warm it up.

▲

MOST of the corporate reports for the first half of 1951 have three points in common: increased sales volume, higher profit before taxes, and lower profit after taxes.

▲

EVOLUTION: The telephone began with its back to the wall, developed until it stood erect, and now rests in a cradle. Which reminds us of the cycle Ambrose Bierce set up when he wrote: "Edible means something good to eat, as a worm to a toad, a toad to a snake, a snake to a pig, a pig to a man, and a man to a worm."

▲

THERE'S a lot of sentiment being expressed for a new "Four-H" club, whose motto is to be:

Help
Hurry
Harry
Home

▲

THE opportunity to make an honest living is getting better and better. Competition in that field seems to be definitely on the decrease.

▲

THE British "Airman's Guide" carries this warning: "The more serious of these offenses are punishable by death, and some of them carry heavier penalties when committed on active service."

COMBAT JOINT EROSION IN HOT METAL MIXERS

Taylor Sillimanite (TASIL) Brick, laid with TASIL No. 301 Cement in the zones of excessive wear (a 13½" thick band around the front, back, end walls and floor of the pour-out spout, and 18" x 18" x 6" blocks for jambs of pour-out spout) is tripling the life of hot metal mixer linings.

Field reports show over 13 months' service each for two mixers lined with TAYLOR SILLIMANITE

Field report on 1000-ton mixer

This company has just completed the third campaign in which more than a million tons each have been tapped on Taylor Sillimanite balanced mixer linings. The last campaign totaled 14 months with not a single brick replaced for the first 12 months. The material and labor costs for the campaign were 20% lower than the best campaign on high-heat duty firebrick linings.

Field report on 500-ton mixer

Previous lining material lasted approx. four months, with less than one-half million tons produced. A Taylor Sillimanite lining has now been in service for 13 months, 9 days, without even a minor repair, handling around 2400 tons of iron per day.

- Despite higher first cost, Taylor Sillimanite Brick linings have paid for themselves through savings in material and masonry costs alone. The real saving however, is in the elimination of frequent mixer downtime. It will pay you in profits to discuss this TASIL application with your Taylor Field Representative.

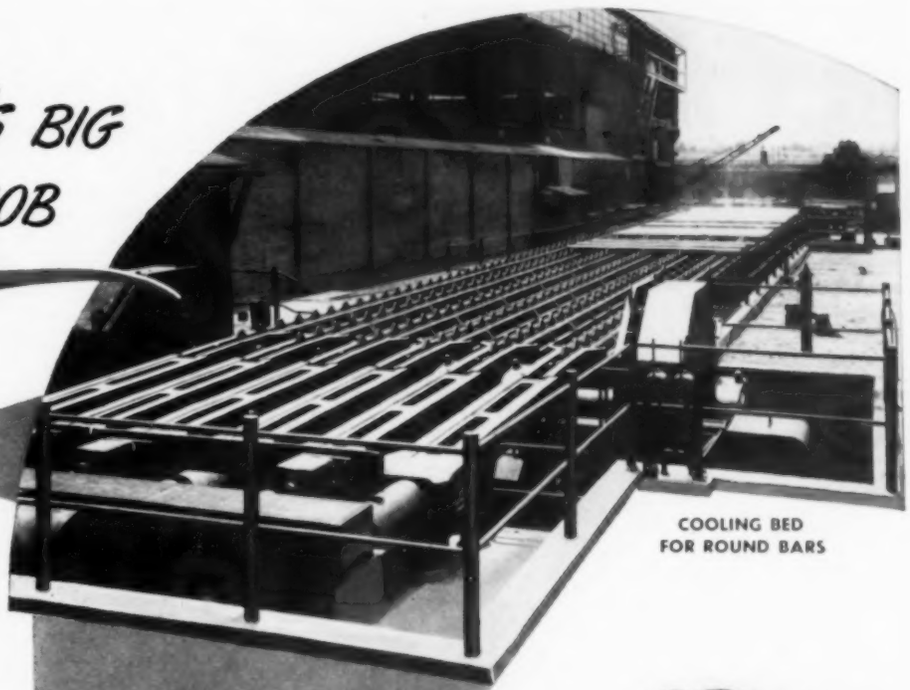
Refractorers to industry since 1864.

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
Hamilton and Montreal

The CHAS. TAYLOR SONS Co.
REG. U. S. PAT. OFF.
MANUFACTURERS OF REFRACTORIES • CINCINNATI • OHIO • U. S. A.

F&Y makes "what it takes"

FOR INDUSTRY'S BIG PRODUCTION JOB



COOLING BED
FOR ROUND BARS

F&Y Products

- PARALLOY ROLLS (PINCH, COILER, TENSION, STEEL MILL)
- HYDRAULIC SLAB AND BILLET PILERS
- STRIP AND SHEET OILING EQUIPMENT
- SHEET SCRUBBER AND CLEANING LINES
- HOT SAWS—ROCKING AND SLIDE TYPES
- HOT BEDS—COOLING BEDS—TRANSFERS
- BILLET EJECTORS—PINCH ROLL STANDS
- SLITTERS—SPECIAL SHEARS AND GAUGES
- TILTING TABLES—TRAVELING AND LIFTING TABLES
- CONTINUOUS PICKLING LINES—ROLLER LEVELLERS
- FURNACE CHARGING EQUIPMENT—FURNACE PUSHERS
- STRIP STEEL COILERS AND REELS—SCRAP BALLERS
- RAILROAD SPIKE FORMING MACHINES—ROLL LATHES
- SHEET GALVANIZING LINES—WIRE PATENTING FRAMES
- STRETCHER LEVELLERS—ANGLE AND SHAPE STRAIGHTENERS
- ROLLING MILL TABLES—GEAR AND INDIVIDUAL MOTOR TYPES
- DUCTILE CASTINGS (80,000 PSI)
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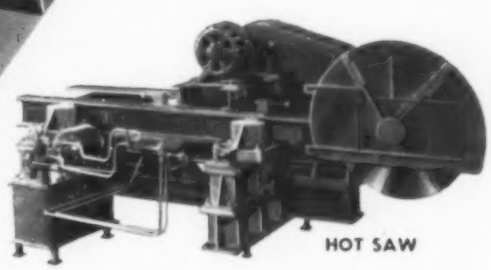

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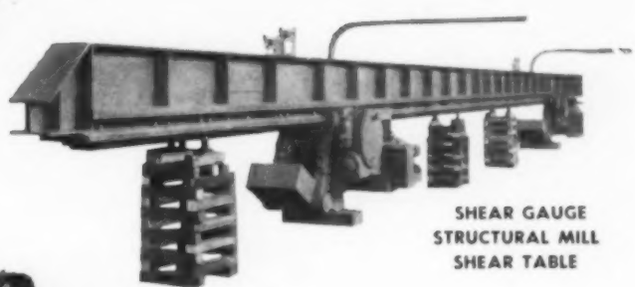

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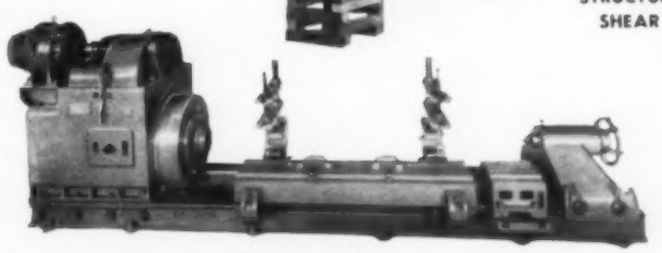

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Iron AND Steel ENGINEER

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In This Issue

Washington Steel Corp.'s 39-In. Cold Mill — by T. S. Fitch, President, Washington Steel Corp., Washington, Pa. 51

Graphite as a Lubricant — by E. S. Glauch, Mechanical Engineer, Joseph Dixon Crucible Co., Jersey City, N. J. 58

Effect of Automatic Controls on Open Hearth Production at Lackawanna — by R. M. Jordan, Assistant to Superintendent of Open Hearths, Bethlehem Steel Co., Lackawanna, N. Y. 63

Program, AISE 1951 Annual Convention 67

New Facilities for Stocking and Shipping Pipe at Lorain Works — by C. Clarke Wales, Chief Project Engineer, National Tube Co., Lorain, Ohio 71

Requirements for a Modern Steel Mill Power Distribution System — by F. H. Wickline, Construction Engineer — Electrical, National Tube Co., Lorain, Ohio 77

Economics of Purchased Power vs Plant Generated Power in the Pittsburgh District — by W. B. Skinkle, Consulting Engineer, Pittsburgh, Pa ... 85

Pollution Control Program for Ohio — by Bruce M. McDill, Engineer in Charge, Water Pollution Control Unit, Division of Sanitary Engineering, Ohio Department of Health, Columbus, Ohio 101

New Developments in Scrap Handling for the Open Hearth — by L. R. Rissler, Section Engineer, Elevator Division, Westinghouse Electric Corp., Jersey City, N. J. 108

Technical Program of the American Iron and Steel Institute 116

Analyzing Blast Furnace Gas 143

Date-Line Diary 145

Industry News 149

Personnel News 163

Equipment News 179

Index to Advertisers 197

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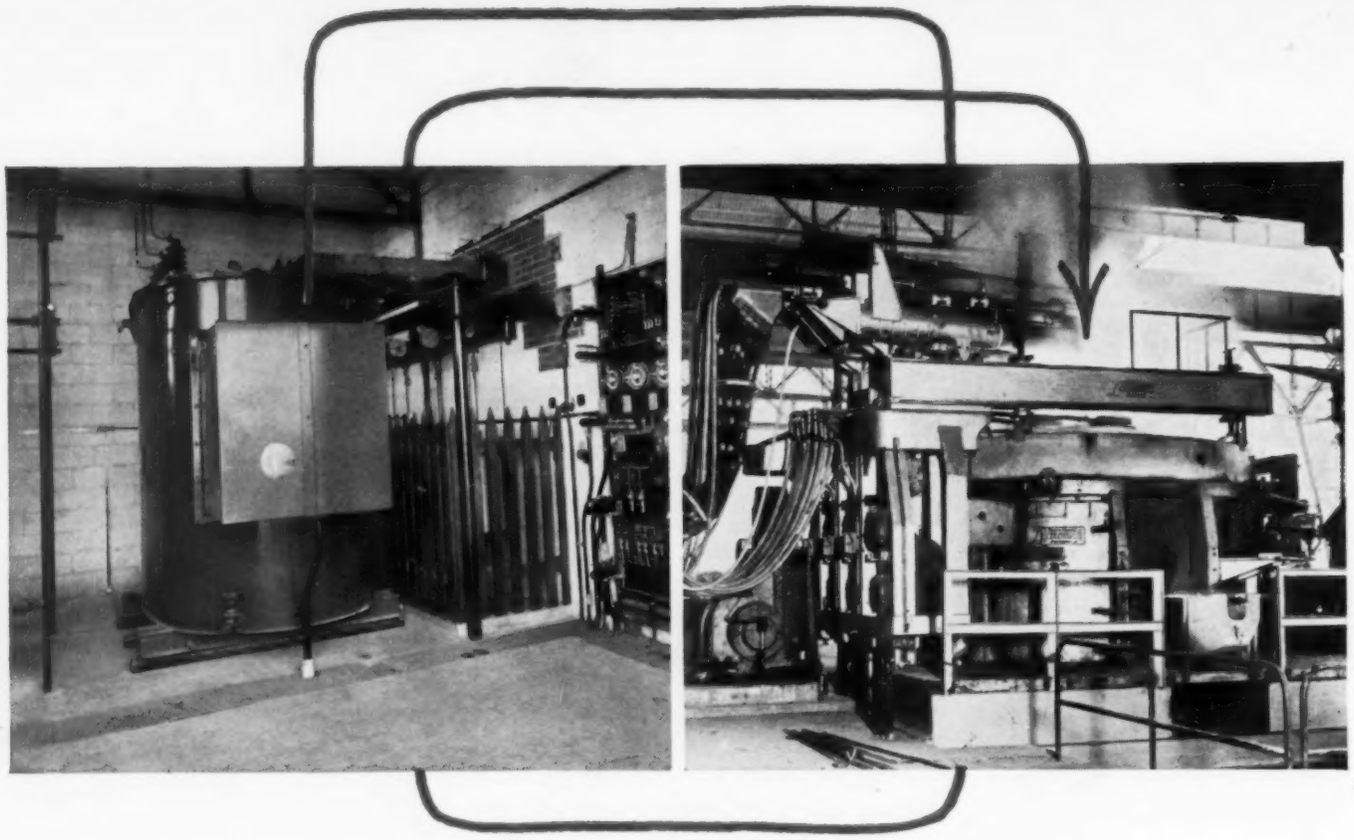

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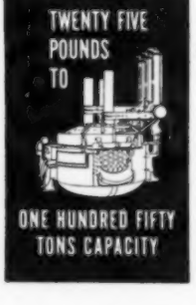


Washington Steel Corporation's

39-IN. COLD MILL

By T. S. FITCH
President
Washington Steel Corp.
Washington, Pa.

. . . . operating results have been very successful on this Sendzimir unit . . . .

▲ CERTAIN over-all aspects of the Sendzimir mill will be discussed before the details because they are interesting and important. Perhaps the most important point is this. Most of us "iron workers" have come to associate productivity and quality with mass. This is very understandable because our modern equipment is, generally speaking, much more massive than the equipment which we employed 25 and 50 years ago. However, it does not necessarily follow, from an engineering point of view, that mass determines either productivity or quality. The Sendzimir cold rolling mill is an excellent example of a relatively small mill that will do better work with less mass. It will be a good thing for all of us if we will remind ourselves occasionally that we do not necessarily have to have a bigger unit to do a better job.

There is another factor inherent in human beings which has a surprising bearing on mill design and the like. We are all subject to prejudice; we become familiar with certain types of equipment and we automatically tend to reject other types even though the facts may indicate otherwise. How many times have we heard it said that something cannot be done simply because we have not done it that way before. This is a difficult problem because it is inherent in human beings, and we should recognize the effect of prejudice in our engineering thinking.

We in America are justly proud of the dynamic effects of competition which relentlessly drives down prices requiring lower costs and which constantly seeks improved quality. Curiously though, there are times when competition inhibits progress because an engineer may say, or more likely management may say, why should we buy this new mill when all of the other producers appear to be satisfied with another type. Fortunately, if the design is good, someone ultimately sponsors it and eventually it is generally used.

It is not our contention that the Sendzimir cold rolling mill is necessarily the answer to all situations, and we do not want to create that impression, although I am confident that those who own these mills are enjoying real advantages at least insofar as the rolling of alloy steels is concerned. Please keep in mind that Washington Steel Corp.'s unit is used exclusively for the rolling of stainless steels. Therefore, our results are not necessarily comparable nor applicable to other mills or other products.

During World War II there was a demand for very thin silicon electrical steel far in excess of our industry's capacity without serious loss of other equally necessary product. Motivated partly by desperation and partly because we liked the engineering, the WPB authorized the rapid construction of a 15-in. Sendzimir cold rolling mill by Armco Steel Corp. It was built in about 6 or 7 months and did an amazingly good job—and it took us off the spot on the silicon electrical deal. When I saw the mill I thought that it ought to be ideal for the rolling of work-hardening alloys such as 18-8 stainless steel. After leaving WPB in March of '44, I tried to persuade my employer to buy a Sendzimir mill but their enthusiasm was not very great primarily because "no one else was doing it." Therefore I decided to start a new company. If I knew then what I know now I probably would not have had the nerve to try, but that is a story of its own to be told some other time.

Many persons have asked me why I was so certain that the mill would work, and there are three reasons which we wish to mention in particular:

1. The theory of using small diameter work rolls to achieve increased reductions per pass was old and had been tried frequently and apparently unsuccessfully. The chief difficulty appeared to be that you could not keep the small diameter roll in line with the backing element, but this mill appeared

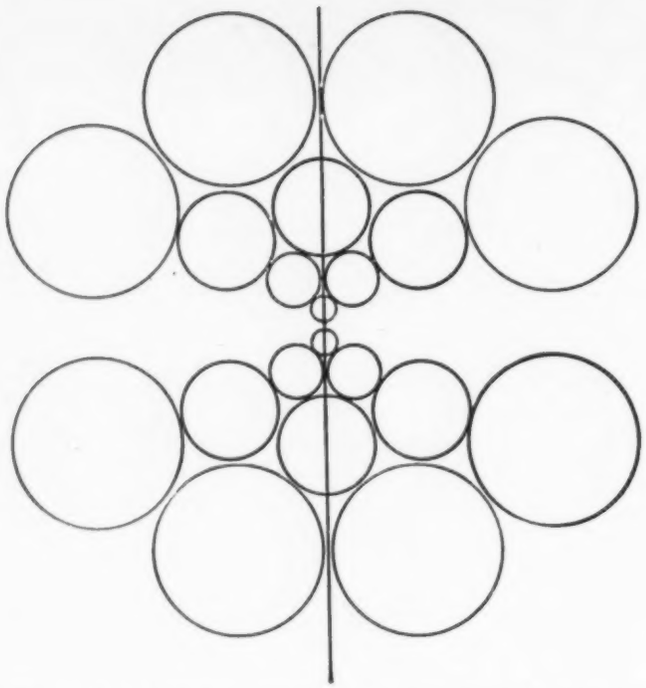


Figure 1 — Sketch illustrates how small work rolls are supported by larger back-up rolls in the Sendzimir mill.

to solve this nicely by having the work rolls nested in the form of a pyramid on top of an inverted pyramid (see Figure 1).

2. One of the prime difficulties with cluster type mills has always been lubrication—or how to get the frictional heat out of the mill to avoid "freezing" the components. Since the designer was literally drowning the mill with oil, we believed the frictional heat could be removed quickly enough.
3. Further, we liked the fact that the mill gave uniform pressure along the entire length of the work rolls as compared to conventional equipment wherein the pressure is applied at the roll necks. In other words, the mill is a flatter mill and should be capable of producing a flatter product.

There are various other reasons why we thought the mill was mechanically sound but the above-mentioned seemed particularly important and persuasive.

In addition, there were also favorable economic factors. In the first place, the original cost of the mill was about 60 per cent of the cost of a reversing 4-high mill to roll the same width. In some companies a few hundred-thousand dollars more or less may not seem very important but I personally consider this regrettable; I think any good engineer should be interested in getting the desired results without unnecessary expenditures of funds. That is good American business.

When rolling 18-8 work-hardening stainless steel on conventional equipment, you can only reduce thickness about 50 per cent before you have to stop and give it an anneal and pickle. So far as we know, no one is doing intermediate annealing and pickling for less than $16 per ton. It is not at all unusual to have as many as two to five intermediate annealing and pickling operations in reducing an 18-8 coil from 0.125 in. thick to 0.015 in. On the Sendzimir mill no intermediate annealing and pickling operations are required and thus very substantial savings are effected on this one factor alone.

Since the coil does not have to be taken off of the cold rolling mill during the course of cold reduction, you have less handling and you do not run the risk of damaging the surface—and, when you are producing flat rolled stainless steel, surface is a number one consideration.

The production cycle is more rapid on the mill. The following story is of interest. We had a customer who failed to read the small print on an export contract; the total value of the contract was about a hundred thousand dollars and he had about 80 per cent of the manufacturing completed; he needed about 14,000 lb to complete the job. The small print in the contract disclosed that he could not collect one dime if he did not have the entire hundred thousand dollars worth of equipment at the dock at the required time. He found this out about 4 o'clock in the afternoon two days prior to the required delivery time. He was desperate; he simply could not find the necessary 14,000 lb of stainless steel sheets. Since we had served him previously, we said we would try to help him. In 5 hours from the time that he called our plant we had completely processed the required material and had it on a truck on the way to his plant so that he was able to complete his manufacturing and deliver the goods on time.

A fast production cycle means that we can operate with a lesser inventory. In addition we have lower manpower requirements per ton because there is less handling during production. Also we have found that by reason of the excellence of the surface that we obtain from this mill, certain of the collateral operations are more efficient; for example, in stretcher leveling hand-rolled stainless steel sheets, one can usually level only one sheet at a time; because of the uniformity of our sheets we can stretcher level as many as 6 or 8 at a time. There has also been a substantial increase in efficiency in the polishing department by reason of the excellence of the surface.

The basic design of the Sendzimir cold rolling mill is illustrated by Figure 1. The two smallest rolls are the work rolls; they are 1⅝ in. in diameter and are friction driven. The work rolls can be changed in less than a minute so that we seldom have any problem on roll marks. If a work roll should be marked we simply put in an unmarked pair.

There are four so-called first intermediate rolls, two top and two bottom; they are 3 in. in diameter and they are also friction driven. Above and below the first intermediates are three so-called second intermediate rolls which are 5½ in. in diameter. The two outside second intermediate rolls, both top and bottom, are the driven rolls. Above and below the second intermediate rolls, there are four sets of roller bearings on shafts which provide rigidity between the alloy steel housing and the inner components. In order to control the distance between the work rolls, the two center sets of bearings, both top and bottom, are on eccentric shafts and are turned by means of a rack and pinion. Of course, as previously indicated, it is a closed system such that the mill can be flooded with oil at all times.

Now I do want, for the benefit of those who may at sometime obtain such a mill, to give you a word of

caution. When the design drawings indicate that the tolerances must be less than usual practice, you must nevertheless adhere to the indicated tolerances or you will be in trouble. We are operating to tolerances that are one-third of those which are considered normal in the industry, but we are doing it day in and day out. It is a matter of proper equipment and proper indoctrination of the organization, together with adequate supervision.

On the subject of lubrication, because it is so important, I will give you a few of the details. We pump 350 gal per minute. We have a 225-gal pump that forces oil through the top bearings, and, in addition, we have a 150-gal pump that sprays oil into the windows of the mill. This oil is a mineral oil, and as time has gone by we have found it advantageous to put in additives which inhibit corrosion and improve lubricity. It is very desirable to have the oil cleaned very carefully, because it affects the surface condition. We also have facilities whereby we can control the temperature of the oil. We deem that to be an advantage and we feel that any such mill should have that kind of equipment, because you may find that certain material will roll a little better at a slightly different oil temperature.

Now let us discuss the matter of shape. On the Sendzimir mill, it is obviously more complicated than it is in the case of a 2-high or 4-high, because of the geometry of the mill. However, the basic principle of rolled shape and strip shape are substantially the same. You have to control it a little more carefully in this mill, and it will require some trial and error. You will find out just which way it is going to work better for each particular width and thickness and hardness and type of material. I assure you that we have worked out the problem of the shape to our entire satisfaction and I believe to the satisfaction of our customers. One interesting thing, we find that our several rollers all follow slightly different techniques; one of them uses a little more back tension than the other rollers, or one may use a little more pressure, but even with some differences in technique, the boys all roll steel; they roll it nicely, and they roll it fast.

Now again, because we designed this mill to roll jewelry, and stainless steel is jewelry relatively speaking, we are not concerned about speed, we are concerned about quality, and also we were trying to keep the first cost of the mill down insofar as we are able. Our top mill speed is 400 fpm. You might be interested to know that when we first started, we hoped to achieve an average rolling speed of 225 fpm. During the first month, we did not average over 125 fpm, but in recent months, we are up to about 275 in average fpm.

Let us talk about this matter of reduction, because after all, that is the essence of the mill. For instance, if I speak of speed, that is a somewhat meaningless statement unless I also talk in terms of reduction, because it is the combination of these two which determines the amount of metal you can roll. At Washington Steel we start with about $\frac{1}{8}$ in. thick hot-rolled annealed and pickled stainless steel coils; the maximum width that we can produce is 36 in. Generally speaking, we will reduce from 0.125 in. down to 0.018 in. in 11 passes. The average reduction per pass will be from 18 to 22 per cent with no intermediate annealing and pickling.

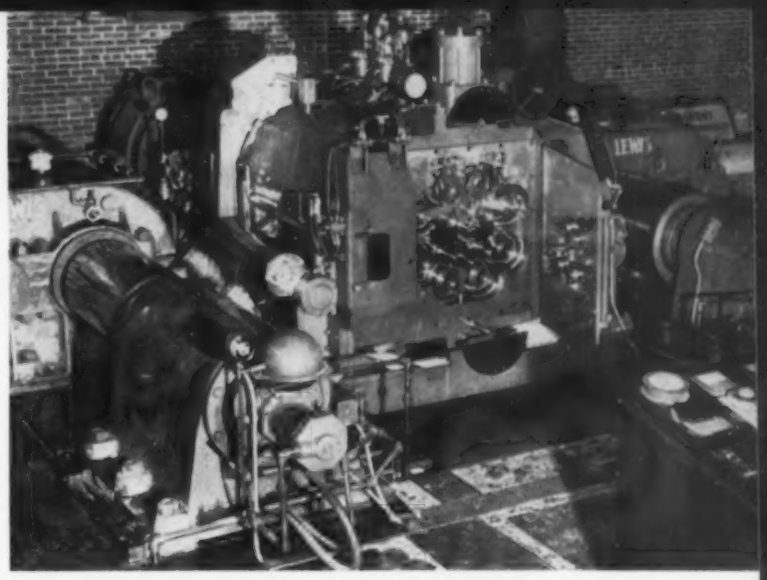
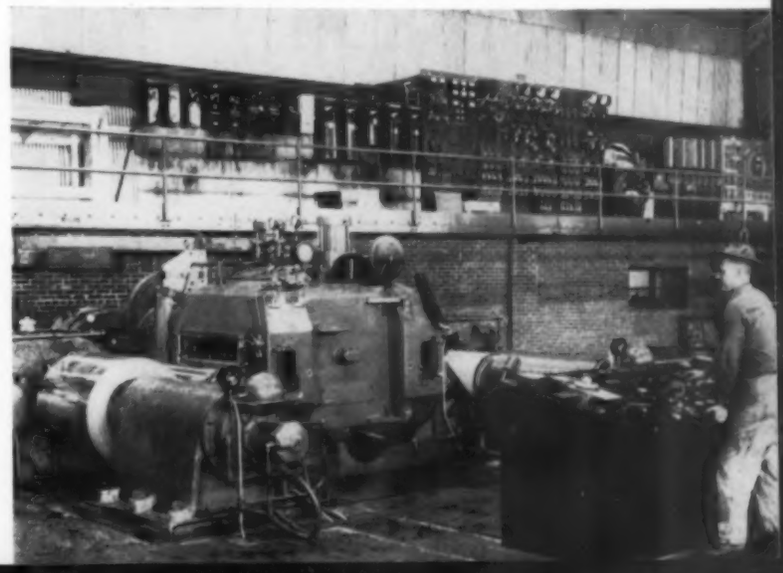


Figure 2 — Mill is shown with the end door open and thus shows the nest of rolls in the mill.

Most of you are aware of the fact that on conventional equipment, you can get roughly 50 per cent cold reduction. I do not mean to say that you cannot get any further reduction after the 50 per cent, but it is uneconomical. You are better off in that case to go on back and give it an intermediate anneal and pickle, and then return it to the mill in a condition such that you can give it some substantial reduction. Our 18-8 stainless steel comes off of the mill at 0.015 in. with a tensile strength of about 292,000 psi; yet, notwithstanding that, we can still take 18 to 22 per cent reduction per pass.

In the following, I do not want to start a "dog fight," and I am stating this merely as my personal opinion, I do want to do a little comparing. Let us assume that we have an 18-8 coil and we started at 0.125 in. and have it down to 0.100 in; here is my personal opinion as to what you can do on various kinds of mills on the next pass in reducibility. On a 2-high, you can get 3 to 4 per cent, on a 4-high you can get 6 to 8 per cent, on a Steckel mill, you can get 8 to 11 per cent and on a Sendzimir, you can get 18 to 22 per cent. Now that makes a tremendous difference, of course; this "ability to reduce" is very, very beneficial.

Figure 3 — The accuracy in the mill is largely due to the roll clusters which eliminate gage variation because of roll deflection.



Here is some of the basic data with respect to the electrical equipment: Power is provided from a 1000-hp synchronous motor driving a 500-kw generator. The main mill motor is a 400-hp motor having a speed range of 500 to 1000 rpm. Each of the reel motors is a 300-hp motor having a speed range of 250 to 500 rpm and all of them are 250-v motors. Since none of us were completely certain as to what the actual loads were on these motors, we installed recording ammeters and found that the average horsepower utilized was 275 on the mill motor and 225 on the reel motors. All motors are set to "kick-out" at 200 per cent overload. Although we do exceed the rated horsepower from time to time, the peak loads are momentary only. At Washington Steel we practice preventive maintenance; the mill is checked from "stem to stern" once each week and we observe no undue deterioration of the motors by reason of the occasional overloading. Please note particularly that our motors are set to kick out at 200 per cent of the rated capacity. To my personal knowledge there is at least one Sendzimir cold rolling mill whereon the motors are set to kick out at 80 per cent of the rated capacity of the motors. In my opinion, they are not getting the tonnage which they should reasonably expect to get off that mill.

There are various methods of obtaining tension control on Sendzimir cold rolling mills, any one of which appears to give satisfactory results. On our mill we obtain entry and exit tension control via regulating type tensiometers between the mill and each reel, then via a silverstat regulator in conjunction with rotating regulator and reel boosters, to maintain a selected deflection from the regular pass line. Hydraulic dampening is provided to keep down hunting. There are two ranges of tension control; the first range is from 2,000 to 12,000 lb which is used for the very thin material and the second range is 12,000 to 50,000 lb total pull and this is the range which is utilized most of the time.

Let us now consider some of the operating results on our mill. Before citing some specific figures, I want to mention that the average starting gauge is 0.130 in., the minimum starting gauge is 0.110 in. and the maximum is 0.160 in. The average finished gauge is 0.023 in., the minimum is 0.005 in., and we do not endeavor to produce anything heavier than 0.078 in. Our average rolled width is 33 in., the minimum is 19 in. and the maximum is 36¼ in. Since most mill men think and talk in terms of tons through the mill, we will give you the operating results on this basis although we find it more convenient to talk in terms of shipped tons. Here are tons "through the mill"—in 1948, 83,710 tons; in 1949, 94,-200 tons; in 1950, 154,980 tons, or a grand total to date of 349,790 tons through the mill. In actual practice we ship approximately 10 per cent of that as the finished product.

Starting with these figures, how does the maintenance cost work out? The first reaction of an iron worker when he sees a picture of a Sendzimir cold rolling mill is to say: "It looks like the inside of a watch—you will not be able to keep it operating—maintenance costs will be unduly high!" In 1948, the total maintenance cost which included labor, materials and overhead was equal to 95¢ per net ton through the mill; in 1949 this same cost was 94¢ and in 1950 it was 68¢. In the present calendar year it would appear that the maintenance cost has again been substantially decreased. Of this maintenance cost, we are often asked particularly about that portion which represents rolls and bearings. In 1948, the roll and bearing cost was 59¢ per net ton through the mill, in 1949, 53¢; and in 1950, 31¢; in other words, we have cut the roller bearing cost in half.

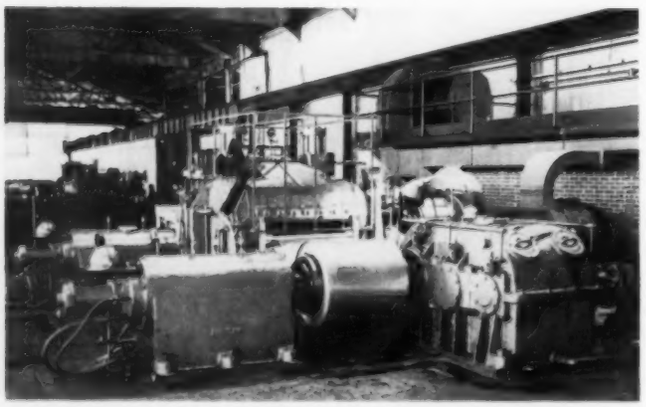
Again speaking of maintenance, here is a comparison that we think is particularly valuable and it is the best answer in our opinion as to whether or not this cold rolling mill is a practical mill unit. Here is the actual lost time for both mechanical and electrical maintenance expressed in percentage of the total available rolling time: in 1948 we lost 4.7 hours of total rolling time for maintenance, in 1949 we lost 1.9 per cent, and in 1950 we lost 1.4 per cent. So far in this calendar year we are very close to 1 per cent. I cannot see why or how anyone can say that maintenance is a serious problem on this mill when such an infinitesimal amount of productive time is lost.

Because Washington Steel was a new company and because we were utilizing a somewhat revolutionary piece of equipment, there was considerable gossip in the industry about our difficulties in getting started. There was a time when as many as 9 out of 10 people in the industry thought we could not make the grade—and there were even some moments when I was not entirely certain. Since rumors have a tendency to wander away from the truth, I want to tell you specifically of some of our difficulties in getting started.

In the first place, we were a new organization; most of us were iron workers but we had to get accustomed to one another—we had to find out how to work together. And of course we were endeavoring to put into operation, a new type of rolling mill on which no one really knew all of the answers—many of the answers simply had to be determined by trial and error. The stress and strain was terrific; most of us had left good jobs, we had reasonably satisfactory incomes so that each time we encountered a setback it made us wonder if this one was "the straw that would break the camel's back."

We were delayed approximately one year in getting started by reason of the difficulties of obtaining some of the equipment.

Figure 4 — The mill requires relatively little floor space.



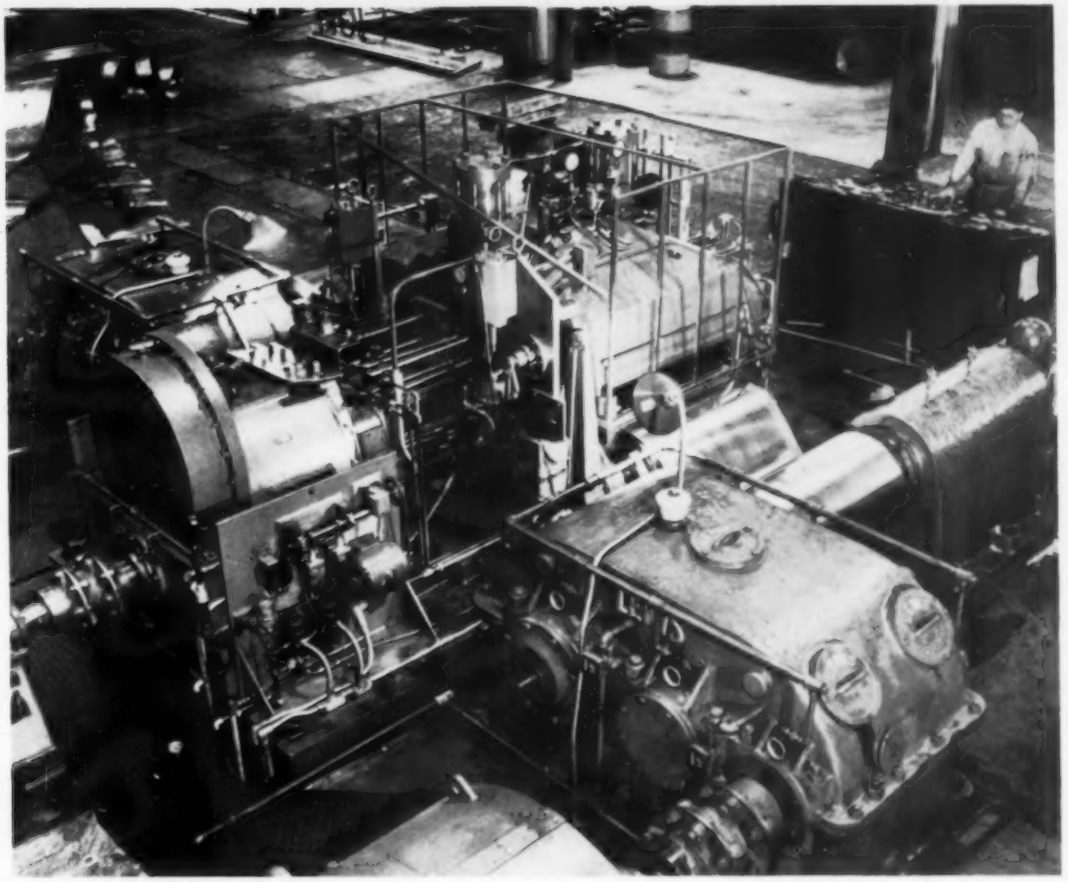


Figure 5 — This view of the mill is taken from the opposite end shown in Figure 4.

Our first major mechanical difficulty was a breakdown of the pinion stand. There is only 8½ in. between the centers of the driving rolls so we did not have too much space for the gears—we were relying on aircraft type gears but we knocked the pinion stand out in October of 1947, after we had been operating about five months. We obtained replacement gears in the plant about the 12th of January, and the following day the gas company shut off our supply of natural gas so that we could not resume operations until February. Since February of 1948 the mill has operated continuously. Actually it is a somewhat moot question as to whether or not the original pinion stand was or was not adequate: we had a lot of cobbles and wrecks and perhaps the strain imposed upon the original pinion stand gears was beyond reason; however, we designed a larger safety factor into the replacement stand. As stated previously, we examine the mill every week and the condition of the pinion stand today is satisfactory.

It was originally intended that we would obtain edge relief during cold rolling by a somewhat novel system. The outer ends of the top first intermediate rolls were tapered and the inner ends of the bottom pair of first intermediate rolls were tapered; then there was a system whereby these intermediate rolls could be moved laterally so that various degrees of edge relief could be obtained. We finally went back to the more conventional idea of putting taper on both ends of all of the first intermediates, and in this way we were able to get satisfactory edge relief and good shape. Obviously the control of the geometry of all of the internal rolls is necessarily very important and frankly, each Sendzimir mill operator has apparently evolved his own particular technique which best suits his purposes.

When we first commenced rolling, we were plagued with heat streaking but this difficulty was eliminated when we doubled the volume of lubricating oil passing through the mill. When we first started we were using bearings as you would eat doughnuts. Here again we had a lot of wrecks, insufficient lubrication and therefore abnormal bearing consumption. However, the set of bearings now in the mill has been in the mill for two years and we consider this entirely satisfactory.

Outside of the fact that the mill isn't such a pretty color as it was when it came from the manufacturer, the mill is actually in better condition today from an operating point of view than it was when we received it. We are backed up with adequate spare parts and, incidentally, I recommend to anyone that buys a Sendzimir mill that you protect yourselves with adequate spare parts, as you should on any equipment. Today at Washington Steel we have no concern about the life of the mill.

You may be interested to know that Washington Steel ships just about 90 per cent of its raw material in the form of finished prime product; and those who know the stainless steel business will recognize that this is a very good yield. We recognize no superior in quality and I believe you will find that there is no one making light gauge stainless steel sheets today who will say that they produce a better sheet than Washington Steel. After all, when you can provide a 36 in. wide sheet, 0.025 in. thick, with less than 0.0002 in. crown—you have a beautiful sheet, and I am happy to report that the trade has apparently recognized the quality of the product from this mill—at least they certainly seem to want to buy all we can produce.

Metallurgically speaking, I do not want to say too

much. There have been quite a number of applications wherein the product from the Sendzimir cold mill seems to have worked better; apparently we do get a slightly smaller and somewhat more uniform grain size off of the very small diameter work rolls. However, I do not personally consider this to be a major consideration and I cannot claim that we have enough factual data to constitute positive proof. I will say, however, that we know of no application where the structure has been deemed to be less satisfactory than the structure of material rolled on conventional equipment.

Now as to conclusions—it is quite obvious that I am sold on the Sendzimir cold rolling mill. I am often asked the question as to whether or not I would favor such a mill if I were operating a carbon steel plant. I am not prepared to take a firm position on that question but there are several points which I would like to make:

1. When you consider carefully the combination of reducibility and speed, you can get a surprising number of tons rolled per dollar of investment.
2. The lesser original cost is attractive.
3. In a carbon steel plant devoted to producing substantial tonnage, a Sendzimir mill might be a real advantage in taking care of odd lots and odd sizes.
4. Anyone who is interested in rolling any metal thinner than 0.020 in. should certainly carefully consider this type cold mill.

It has been the writer's privilege to observe quite a number of such cold mills in operation and I have noticed that many of the operators are not getting as much tonnage through their mills as they should. It is my understanding that Washington Steel is getting more tonnage per dollar of investment and per inch of width than any other such mill. There are reasons for this. In the first place, we had to—our business lives depended upon it; and secondly, we had no prejudices about getting more production. Of course, we do not have other types of rolling mills for primary reduction as so many other producers do; for them the problem is not necessarily easy. For example, if you have a Sendzimir mill producing 20 tons a turn of stainless steel sheets beside a conventional mill turning out only 10 tons a turn of the same product, you have a rate problem as far as the rollers are concerned. If you have an incentive system, that will further complicate your problem if you have several kinds of mills. However, I repeat that it is neither good business nor good engineering to lose production in these critical times.

DISCUSSION

PRESENTED BY

A. F. KENYON, Steel Mill Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.

C. JANSEN, Industrial Engineer, American Steel & Wire Co., Cleveland, Ohio.

T. S. FITCH, President, Washington Steel Corp., Washington, Pa.

A. F. Kenyon: The author has presented a comprehensive description of the Sendzimir type reversing cold reduction strip mill at the Washington Steel Corp., together with his reasons for the decision to install that type of mill, and a careful analysis of the operating results. As such it should be of particular value and interest to other mill operators.

Some further comments with regard to the electrical drive equipment for this mill may be of interest. The drive for the mill rolls is of 400 hp capacity, geared to provide a mill delivery speed range of 200/400 fpm by shunt field control of the mill motor. Thus the *horsepower* available is constant over this range, but the *torque* capacity varies inversely with the speed and at 400 fpm the available mill torque is only half what it is at 200 fpm base speed. Similarly the reel drives are arranged to provide 300 hp capacity over the 200/400 fpm mill speed range, this corresponding to about 48,000 lb rated full load winding tension capacity at speeds from standstill up to 200 fpm and then varying inversely with the speed down to 24,000 lb tension capacity at 400 fpm.

At the time the mill was laid out, this arrangement of the mill and reel capacities was felt to be ample, as it was thought that the early passes requiring large mill torques and reel tensions would be made at base speed or less; where large mill torque and reel tension capacities were available, and that the later passes to be made at higher speed would require lower mill torque and reel tension. Upon putting the mill in operation, it was found that almost as large tensions were desirable for the finishing passes as for the earlier roughing passes, so that the operating speed on these finishing passes had to be somewhat restricted to keep within the reel motor capacities. Thus it probably would have been desirable to make the reels with constant tension capacity over the entire speed range, although of course this would have necessitated reel motors rated 500-600 hp.

It is to be noted that the 48,000 lb reel tension capacity is quite large as compared to the usual reel tension rating on similar width conventional four-high reversing mills, and apparently it is desirable to have large reel tension capacity to assure successful Sendzimir mill operation. On another 40-in. wide Sendzimir mill, the original installation provided a reel tension capacity of about 39,000 lb. The mill design provided for larger mill speed range and coil build-up than were found necessary in operation, and by making relatively simple changes in the reel control, the tension capacity was increased to 49,000 lb with some restrictions in the maximum speed and coil size. The winding reel tension capacity on several large Sendzimir mills ranges from 900 to 1250 lb/inch mill width, while on conventional four-high reversing cold strip mills, the reel capacity seldom exceeds 500 lb/inch mill width and on some is as low as 250 lb/inch.

C. Jansen: Mr. Fitch talks about manpower requirements; how do you man the mill and what weight of coils do you use?

T. S. Fitch: We like to start with eight thousand pound coils; actually, we have to use coils as light as about 3500 lb, and the maximum is 8600 lb. Two men operate the mill.

C. Jansen: I noticed in your paper that it is prevalent in the steel mill industry for the roller to set the rolling practice. I wonder why it is that the roller has to

set the practice; why not make a standard practice out of it?

T. S. Fitch: You pay off on results; we find that by giving the boys a little chance to use their initiative, that they seem to do better work. And we are well satisfied with the results the boys are giving us.

C. Jansen: Are they on incentive?

T. S. Fitch: Yes. We have an incentive plan that we think is unusual. We have a "par" figure—man-hours per ton of shipped product, and then we take the actual man-hours per ton for the month and we pay everybody in the company—sales department, operating, maintenance, everybody except the officers of the company—on the basis of that one incentive. It is a simple calculation. You make it once a month. The boys understand it, and you should see them work. There are many incentive systems that you have in your plants that you do not understand yourself. Anyone can understand this one, and our boys have made as much as 41 per cent over their base pay, but the months in which they make more than the base, our unit costs are lower. I would be pleased to see them take home a hundred per cent.

C. Jansen: How do you get the leader strip fastened on?

T. S. Fitch: We weld it on with hand welding. We had the problem of deciding whether to use the collapsible type mandrel or solid mandrel. The theoretical pressure of building up the coil with tension of 50,000 lb, front and back, was so tremendous. It ran into something like 40,000,000 lb for the mandrel collapsing pressure, and we were afraid we would get the steel on a mandrel which would not collapse. So, we used the solid type mandrel with an outboard bearing and wound the coil up first on the mandrel and, before winding it, we put on a leader strip which we weld by hand.

Member: Do you say it is easier to make the larger reduction?

T. S. Fitch: Economically, we prefer to make the larger reduction.

Member: Is it mechanically easier to take the one big reduction if your equipment is big enough for two smaller ones?

T. S. Fitch: You have to work certain things out depending on how your shape and how the edge of the strip is running. If you have a bad strip with cracked edges, you have to take a little less reduction, but generally speaking, we will average around 18 per cent. You are right to this extent; because of the tension control, we have a very substantial tension, and it is hard to start out and take a very small reduction. On our mill for instance, to take a half-thousandth off is very, very difficult. That is not because the mill will not do it, but because we have so much tension.

Member: You mentioned a reduction of 18 to 22 per cent—we do it on straight chrome also; would you care to tell us what your reduction would be on a grade like 316?

T. S. Fitch: We have not rolled Type 316 or 310 but it does not seem to make much difference. We got substantially the same reduction.

Vernon Hill: It is the same thing. Most of your problems on 310 and 316 is in the slabbing—if you give us a good coil with good edges, we will roll it using the same technique and cycle as we do on Type 302.

Plan to attend!

Annual Convention

Association of Iron and Steel Engineers

October 1, 2, 3 and 4, 1951

Hotel Sherman

Chicago, Illinois

GRAPHITE AS

. . . . graphite lubricants, properly applied, can solve some tough mill lubricating problems . . . .

▲ THE first use of graphite as a lubricant is lost in antiquity. The name "graphite" was first given to the mineral by the mineralogist Werner in 1789. It is well, however, to mention that graphite (and unless otherwise stated, references apply only to the natural mineral form) is of the carbon family. It is also known under other names such as blacklead, silver lead and plumbago. These names are still frequently used, particularly in the foundry trade. The grades used for foundry work are in most cases of lower quality and blended with binding agents.

Graphite, one of the softest minerals, has a hardness of ½–1½ on Moh's scale. Diamond, also of the carbon family, has a hardness of 10 on the same scale.

Graphite is now being used throughout industry for a multitude of purposes. It is uncutous, a feature which often results in the reference "greasy" to be applied to graphite, although it is free from oil or grease in its original form.

Graphite marks readily, burns slowly and is almost chemically inert. It is a good conductor of heat and electricity, has excellent weathering properties and mixes readily and homogeneously when combined with oils or greases. It has a specific gravity of 2.1–2.5.

There are three distinct forms of natural graphite: flake, vein and so called amorphous.

Flake graphite is usually found disseminated in schist and the ore, as mined, yields only a few per cent which is suitable for use in industry. An outstanding example of flake graphite is that obtained from Madagascar. Flake graphite is, of course, found in many other locations, but Madagascar is our most dependable source of supply. Flake graphite from this source is preferred for use in the manufacture of crucibles. Packing manufacturers also prefer this grade for use as a lubricant in many of their products.

Vein graphite, another form, is best represented by the grades imported from Ceylon. Graphite from Ceylon is usually imported in lump form, although grades known as chip and dust are also imported. Ceylon graphite is found to vary in structure and is classified as carbon, crystalline, crucible, and needle lump.

The third form of graphite is referred to as amorphous because of its earthy appearance. Extensive deposits in Mexico and Korea have been our principal sources of supply. This type does not appear to the eye to have a crystal structure. Under the microscope, however, crystals can be detected and this accounts for the term "cryptocrystalline" being applied to amorphous graphite.

Graphite varies not only in structure, but in purity as well. The kind of associated mineral is as important as the purity. Flake graphite of 85–87 per cent graphitic carbon is used in manufacture of crucibles and retorts. For use in lubricants, packings and similar products, the higher carbon grades are preferred.

Graphite from Ceylon is usually imported as 90–95 or 97–98 per cent lump. Ceylon chip and dusts ranging from 55 to 90 per cent are also imported. Amorphous graphites usually run from 80 to 85 per cent graphitic carbon.

It would probably be of interest to mention some of the uses for graphite other than lubrication. Pencils, which everyone uses at some time or other, are referred to as lead pencils. The "lead" in pencils is a combination of graphite and binders. All three forms of graphite are and have been used in the production of pencils.

In crucibles, retorts, stopper heads and similar refractory products, graphite gives the product the following properties: (1) high thermal conductivity, (2) high electrical conductivity, (3) low thermal expansion, (4) high refractoriness, (5) high resistance to metal and flux attack, and (6) thermal plastic properties at elevated temperatures.

Manufacturers of motor and generator brushes use graphite in many of their products since it has useful electrical properties and is self lubricating. In dry cells graphite is mixed with manganese dioxide to produce a conductive mixture. In paint graphite is used as a pigment and also as a protecting medium. Many other uses include resistors, coatings for cathode ray tubes, powder glazing and pelleting, as a carbon raiser in steel manufacture, in production of parts by powder metallurgy (steel and nonferrous), coating roofing granules, brake linings, gaskets, stove polish and other special products.

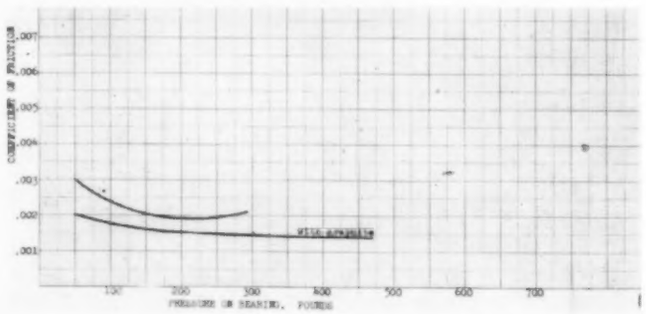
QUALITY OF GRAPHITE TO BE USED IN LUBRICANTS

That the quality of the graphite used has an effect on its efficiency can readily be assumed. The nature of the associated minerals has a definite relation to the value of the graphite.

The mere fact that one graphite has lower ash content than another does not necessarily indicate that same is better for lubrication purposes. Tests indicate, generally, that with natural graphites, the lower the percentage of impurity the lower the loss in weight.

Table I shows results of tests conducted on the Timken lubricant tester. The object of this series of

Figure 1 — Curve shows test results which give coefficient of friction for kerosene with or without graphite with the shaft running at 475 rpm.



A LUBRICANT

By E. S. GLAUCH

Mechanical Engineer

Joseph Dixon Crucible Co.

Jersey City, N. J.

TABLE I

RELATIVE LOSS IN WEIGHT ON BLOCK

Graphite type	Graphitic carbon %	Speed, rpm	Load, psi	Avg loss in weight, mg	Particle size through 325 mesh, %
Amorphous	40	800	829	8.70	75
Amorphous	69	800	866	8.55	65
Amorphous	85	800	1009	7.65	85
Flake	85	800	1014	3.70	95
Flake	99	800	1214	2.60	94
Crystalline	98.5	800	1263	2.50	99
Artificial	95.5	800	639	19.85	100
Oil only	....	800	935	4.55	....

Viscosity of oil	315′ @ 100 F
Pour test	–15 F
Open flash point	370 F
Gravity	23.5 Baume

tests was to endeavor to determine possible wear on bearing and its relation to purity and type of graphite.

Standard Timken rings and steel blocks were used on all tests. Bronze blocks, machined to fit rings, were first tried, but it appeared difficult to get proper alignment. Tests were therefore made with steel blocks.

The loads shown on chart were determined after completion of test by measuring width of scar. The initial load was in all cases (according to Timken Chart) 2500 psi.

Tests indicate that wear, with natural graphites, bears a definite relation to percentage and type of impurity in the graphite.

Kent, 9th edition states: "Graphite in a condition of powder and used as a 'solid lubricant,' so called to distinguish it from liquid lubricant has been found to do well where the latter failed." Rennie in 1829 says, "Graphite lessened friction in all cases where it was used." General Morin, at a later date, concluded from experiments that it could be used with advantage under heavy pressures; and Prof Thurston found it well adapted for use under both light and heavy pressures when mixed with certain oils. It is especially valuable to prevent abrasion and cutting under heavy loads at low velocities.

Prof W. F. M. Goss, of Purdue, in a series of tests in 1901, obtained results with various mixtures of sperm oil and graphite, which indicated a reduction in the co-efficient of friction when using graphite. The pressure on the bearing was approximately 200 psi projected area. The test was conducted at a speed of 120 to 130 rpm. Table II shows figures taken from the Goss report.

TABLE II

Per cent graphite by weight	Average speed, rpm	Temperature rise per hr, per degree F	Co-efficient of friction
0	120.1	26	0.00284
1.7	129.8	35	0.00268
2.1	125.3	20	0.00253
3.1	130.9	30	0.00269
3.9	127.0	28	0.00215
5.6	127.7	36	0.00235
6.9	130.1	32	0.00261
8.5	128.3	36	0.00421

From these figures it can be concluded that for a bearing operating at pressures in the range of 200 psi, a lubricant containing 4 per cent of graphite is more efficient than the liquid lubricant alone, or mixtures containing either a lesser or greater percentage of graphite.

At a later date, Prof Goss conducted a series of tests on a ball thrust bearing operating at 475 rpm. In this series of tests, he used kerosene, lard oil and vasoline to which had been added 4 per cent of finely pulverized graphite. Curves showing results are shown in Figures 1, 2 and 3.

As the result of these tests Prof Goss says that the following general conclusions may be drawn:

"A combination of graphite and lard oil makes up a lubricating mixture which, when applied to ball bearings, will accomplish everything which lard oil alone

Figure 2 — Curve shows test results which give coefficient of friction for lard oil with or without graphite with the shaft running at 475 rpm.

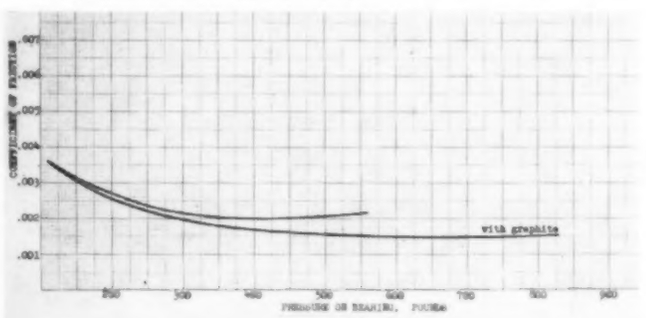
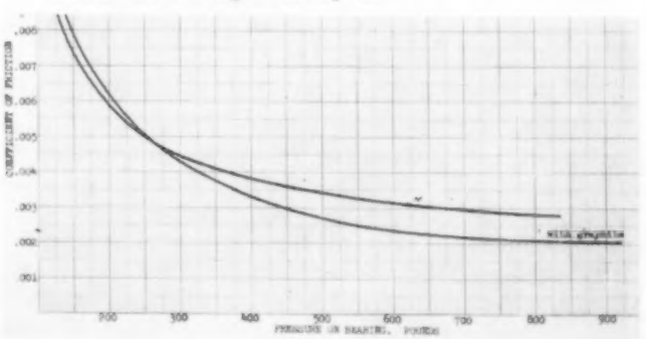


Figure 3 — Curve shows test results which give coefficient of friction for vasoline with or without graphite with the shaft running at 475 rpm.



will do and which, at the same time will give a lower frictional resistance of the bearing and permit a large increase in the load which it may be made to carry. An oil as light as kerosene, when intermixed with graphite, will be converted into an effective lubricant for ball bearings when operated under light or medium heavy pressure.

"Even so viscous a lubricant as vaseline will better perform a given service in the lubrication of ball bearings when supplemented by small amounts of graphite. The bearing to which the mixture is applied will work with less frictional resistance and will carry a heavier load than when vaseline alone is used."

The above references are presented primarily to indicate that graphite has been used in the field of lubrication for many years.

The continued use of graphite in lubrication after more than one hundred years surely indicates that benefits are derived from its use.

Bearings and journals that appear to be perfectly smooth to the eye will under magnification, appear as a series of grooves, sometimes quite irregular. In a 360 degree bearing, operating under light loads, a fluid lubricant will serve to prevent metal to metal contact. As pressures increase and in bearings of less than 360 degrees, the oil film is ruptured. For that reason, greases must be used. In some cases, to maintain the film, the lubricant is so viscous as to cause a drag, which results in high power consumption.

Some years ago the writer presented figures, before the Chicago Section of the AISE, which clearly indicated that graphite lubricants reduced, under actual operating conditions, power consumption up to 25 per cent, with no other change in operation other than the lubricant. (See Iron and Steel Engineer, May 1931).

In the mill tests, conducted by the writer, he noted the difference in the lubricant film on the roll necks. Many of the non-graphite greases produced a rather thick film. The graphite grease film, was much thinner and after a short period of operation the neck had a gun metal color.

On one test the roller reported the necks were getting bright, they having been told that bright necks meant lack of lubricant and would result in a hot neck. Checking it was found the neck had acquired a graphite film and was operating at normal temperature. The graphic wattmeter indicated a considerable reduction in power consumption. This mill is still lubricated with graphite grease and has been for over twenty years. Many other mills where similar tests were conducted over twenty years ago are still being lubricated with graphite grease.

Graphite, due to its ability to fill in the low spots on both journal and bearing, has enabled operators to keep equipment operating which otherwise would have to be shut down for overhaul.

Graphite will lubricate bearings operating at temperatures which will carbonize oils and greases.

Tunnel kilns, annealing furnaces, continuous core ovens and similar units can be and are being lubricated with graphite. Since it is sometimes difficult to apply dry graphite to bearing surfaces, a vehicle or carrier is used which will vaporize without leaving carbon residue. Graphite in paste and rod form is supplied to users and manufacturers of bearings which must operate without oil or grease. Solid graphite bearings are used where excessive heat or other operating conditions prevent use of oil or grease.

Graphite lubricants are used in extrusion of various metals, in die forging, in wire drawing, and shell nosing.

Many steel plants operate railroad equipment, therefore it would be well to mention some uses for a graphite product, used for lubrication, which is neither an oil or grease. This product, supplied in paste form, is diluted by the user with a thinner which can be turpentine, paint and varnish makers' naphtha, carbon tetrachloride or similar material.

The surface on which this product is to be applied should be free from oil or grease so the film will dry hard. After drying, a graphite film provides dry lubrication and does not collect and hold dust and dirt which frequently is the case with non-drying oils or greases.

This product is being used on center castings, diaphragms, buffer assemblies and pedestal jaw liners on cars. It is also used on center castings, pedestal jaws and other parts of diesel locomotives where sliding friction occurs.

Many railroads are now using this product for lubrication of switch plates. In this service, the dry coating reduces the cost of lubrication, since it does not require frequent renewal, as is the case with black oil which has been used for many years. Some railroads have reported reductions up to fifty per cent.

In conclusion, the following summarizes the properties of graphite:

1. Graphite is a solid lubricant.
2. All grades are not recommended for use in lubrication.
3. Graphite mixes readily with oils and greases.
4. Graphite does not chemically react with other materials.
5. A metal surface that has been coated with graphite is more readily wet with oil or grease.
6. Graphite will withstand pressures and temperatures which are beyond the range of oils and greases.
7. Graphite lubricants will, in most cases, reduce power consumption and maintenance costs.

DISCUSSION

PRESENTED BY

C. E. PRITCHARD, Chief Lubrication Engineer, Republic Steel Corp., Cleveland, Ohio.

E. S. GLAUCH, Mechanical Engineer, Joseph Dixon Crucible Co., Jersey City, N. J.

D. E. WHITEHEAD, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.

JOHN F. BOAL, Lubrication Engineer, Carnegie-Illinois Steel Corp., Homestead, Pa.*

V. A. CROSBY, Climax Molybdenum Co., Detroit, Mich.

***At time of presentation of paper.**

C. E. Pritchard: I am well aware of the benefits derived from the usage of graphite for bearing surfaces

where you have surface defects that can be made up into a virtually smooth surface by such additions. Likewise, by virtue of our own field experience, we have had certain ramifications in the usage of graphite that still puzzle us, and I would like to project a question to Mr. Glauch. What is the optimum percentage and type of graphite that can be utilized in an antifriction type bearing? We have found that graphite deposits will become accumulative in the bearing by subsequent additions of a given lubricant employing graphite as a filler. How can you account for the relatively high rate of wear experienced in the usage of conventional graphite type greases in antifriction bearings?

The experience offered, by our personal observations would indicate that the particle size is a very definite and a given factor that must be considered in such evaluations.

I would also like to ask the question as to whether or not the specific quality of a specific type of graphite enters into the particular wear factor that I mentioned previously? According to one of the slides shown, flake graphite offered a remarkable difference from the standpoint of wear score diameter. Will this be carried out in all operations irrespective of the particular type of metal to metal combinations, design and surface finishes employed and so forth?

E. S. Glauch: Mr. Pritchard refers to the value of graphite in lubricants in such cases where surface defects exist either on the bearings or journals. This definitely is one instance where the value of graphite in lubricants has been proven. The graphite being a solid, fills the defects and any other irregularities in the machined surface providing a smooth surface which can then be more readily lubricated with either oil or grease. Graphite being a solid, once it is forced into the irregularities or surface defects, is not squeezed out by the bearing pressure as would be the case with oil or grease. The graphite also aids lubrication in that it prevents the irregularities from breaking the oil or grease film.

Mr. Pritchard asks what the optimum percentage and type of graphite is that can be used in antifriction bearings. This question cannot be answered by a single statement due to the varied application of such bearings.

We currently are not supplying graphite lubricants for any heavy duty applications involving antifriction bearings in steel mills. There may be applications of this type where others are supplying graphite lubricants but the writer is not familiar with them.

We have supplied graphite lubricants for use in antifriction type bearings in such cases as mine car units, high speed hammer mills and other similar applications. We have supplied lubricants for these applications to some customers for more than twenty-five years. This indicates to the writer satisfactory performance, for surely had they had any difficulty with excess wear on bearings, they would have discontinued the use of the graphite lubricant. For these applications, the lubricant contains 4 per cent of graphite which is ground so that a minimum of 97 per cent will pass a 325 mesh sieve and the graphitic carbon is in the range of 97 per cent.

Mr. Pritchard's reference to the accumulation of graphite deposits would indicate that perhaps the lubricant contained too high a percentage of graphite or the lubricant had been applied too frequently or even possibly that the base lubricant or grease had broken down permitting separation. His statements with reference to rate of wear, also could be caused by several factors. One is the wrong type of lubricant, the lubricant containing too high a percentage of graphite or the quality of the graphite contained in the grease.

Mr. Pritchard also asked the question whether the specific quality, type or size of graphite has relationship to the wear and believe that the figures shown on Table I would definitely indicate that these are factors that must be considered.

D. E. Whitehead: You mentioned that you did not know of any specific large antifriction bearing steel mill application involving the use of a graphitic grease. I can think of one, the 52-in. structural mill at Homestead. This mill is equipped with large antifriction vertical roll bearings, and graphite grease had been used for years.

John F. Boal: Many steel plants have long relied upon graphite lubricants for certain of their specialized applications. Graphited oils are often used to successfully lubricate under high temperature conditions such as are encountered in conveyors and cars passing through furnaces, transfer chains handling hot steel and for hot drawing, rolling and forging operations.

A number of different types of greases containing graphite have performed well in the lubrication of certain steel mill equipment. These greases have ranged from the heavy consistency block types widely used for roll neck lubrication on older mills to the softer type greases such as are used in modern centralized systems for delivery of grease to the bearings. Some of the applications where graphited greases are often used in steel plants include plain roll neck bearings, plungers on hydraulic pumps, accumulators and on hot bed skids.

The addition of graphite to certain soft greases seems to help the thin grease film on bearing surfaces resist the washing action of water; also the graphite acts as a parting material and reduces the tendency toward the galling of bearing surfaces under conditions of boundary lubrication. Both these conditions are normally encountered in plain roll neck bearings where water sprays are used for cooling of the roll necks and as a result graphited greases have found fairly wide acceptance for this application.

Mr. Glauch has mentioned that there are several general types of graphite and he has indicated that certain of these types are preferred for use in lubricants. The maximum particle size of the graphite and the amount and character of the non-graphite material present all have a bearing upon the suitability of the graphite for a given grease application.

Some steel plants have experienced cases in which the use of an improper type of graphite in the grease has resulted in the grease exhibiting an abrasive tendency. In one plant in which a graphited grease was being applied to plain roll neck bearings through an automatic centralized system, an excessive amount of wear took place in the closely fitted and hardened pistons and check valves of the lubricant pump, making an early replacement of these pump parts necessary. During the time this grease was being used, however, the quality of the lubrication on the plain roll neck bearings was entirely satisfactory.

This emphasizes the importance of the grease supplier giving due consideration to the selection of the correct grade of graphite for use in greases and particularly

those which are to be dispensed through centralized systems. It also points to the need for close control by the manufacturer of the graphite to insure the quality of the materials being sold for grease applications.

E. S. Glauch: With reference to Mr. Boal's comments that the use of improper type of graphite has resulted in excessive wear on valves and pistons of automatic centralized systems, this can be quite serious.

It has been brought to our attention that at times lubricants have been produced for use in such systems where the grade of graphite was one which we normally would not recommend. We had one such instance several years ago where we were called upon for our recommendations. We were not supplying the grease or the graphite. In that instance, our examination of the grease indicated that the graphite used was of the amorphous type and contained approximately 80 per cent graphitic carbon. The percentage of graphite in the lubricant was probably higher than it should have been for that particular application. It was our recommendation that this particular company have their lubricant supplier produce for them, or supply them, a grease containing a graphite which would be minus 325 mesh and have a graphitic carbon content in the range of 95-97 per cent.

The subject of wear on parts of centralized lubricating systems is being investigated, however, it will probably be some time before results of tests are available.

I might mention that about the same time that we were conducting tests, the results of which are reported on Table I, one of the major oil companies was conducting a similar series of tests also using a Timken machine. They, however, used a ball bearing and operated their tests over a longer period of time. The final results of their test and our test checked very closely.

As both tests indicated, natural graphites showed less wear than tests using artificial or manufactured graphite. The oil company results indicated that when they tested the graphites of a manufactured variety, even though the graphitic carbon content was in a range of 99 per cent, the wear was much greater than on any natural graphite of similar graphitic carbon content and was even much greater than the test they ran on amorphous graphite running approximately 80 per cent in graphitic carbon. In their tests, the wear on the balls, when using manufactured graphite, was so great that when the test was completed they did not have to disassemble the bearing to remove the balls for weighing since the balls fell out due to the reduced diameter caused by the excessive wear.

V. A. Crosby: What has been done with molybdenum disulphide in combination with graphite or as an alternate for graphite?

E. S. Glauch: The writer has had no personal experience with molybdenum disulphide either by itself or in combination with graphites. I do know that this material has been used in lubrication with excellent results reported, but have also seen one or two references where results were not outstanding. Undoubtedly this material has certain properties which may make it useful for certain applications but as stated above, I have had no personal experience with its use as a lubricant.

THE ROLE OF BORON STEELS IN THE PRESENT EMERGENCY*

By P. R. WRAY

Metallurgical Engineer — Alloy Steels

United States Steel Co.

For the majority of applications for the constructional alloy steels, boron can probably replace a sizable quantity of nickel, chromium, molybdenum, and other critical alloys where their presence is necessary only for adequate hardenability. The advantages in replacing other alloying elements with boron, aside from alloy conservation, are: (1) the improved hot and cold working, (2) shorter annealing cycle, and (3) improved machinability, all of which should result in economies. In replacing higher alloy contents in carburizing steels, boron contributes to simplified treatments by shortening the time cycle for annealing and minimizing retained austenite and undissolved carbides in the carburized case.

Boron steels require more care in their selection and treatment than do the conventional alloy steels, because of the following factors:

1. Hardenability must be adequate, so that a tempered martensitic structure is obtained at the location where the highest stresses are encountered. If other structures are obtained in heat treatment, mechanical properties, particularly toughness, may be impaired to an even greater extent than in conventional alloy steels.
2. Boron exerts a pronounced effect on the hardening properties, but little or no effect in retarding softening at elevated temperatures. This usually necessitates a lowering of the tempering temperature to attain a desired hardness or strength.
3. Boron cannot perform the same function as does molybdenum, vanadium, or tungsten of contributing strength at elevated temperatures and, consequently, any attempt to replace steels high in these elements with boron steels for high temperature applications is not considered practical.
4. Because of a decreasing hardenability effect of boron with increasing carbon content, the hardenability of the case of a carburized part may be insufficient. Some improvement can be effected by limiting the maximum carbon in the case to about 0.90 per cent carbon.
5. Carburizing, followed by direct quenching, may decrease the hardenability of the core. Either delayed quenching (i.e., slow cooling to about 1550 F prior to quenching) or double treatment seems to be an effective remedy.
6. Several new series of boron alloy steels have been developed to conserve our critically short alloys. By concentrated attention to details, it is felt that these steels will have fairly wide application.

*Abstract from paper of same title.

Effect of Automatic Controls

ON OPEN HEARTH PRODUCTION AT LACKAWANNA

By R. M. JORDAN
Assistant to Superintendent of Open Hearths
Bethlehem Steel Co.
Lackawanna, N. Y.

. . . . automatic combustion controls and automatic reversal offer a means of obtaining more efficient open hearth operation after other ills have been corrected. . . .

▲ THE open hearth department of the Lackawanna plant of Bethlehem Steel Co. consists of thirty furnaces divided into three open hearth shops. No. 1 open hearth was built in 1906 and has fourteen furnaces that tap 140 tons per heat. Prior to the installation of the new panel boards, all that the furnaces had in the way of instrumentation were liquid-fuel recorder-controllers, coke-gas meter and two steam-pressure gages. Seven of the furnaces were equipped with forced-air fans with indicating flow gages and three of the furnaces were equipped with furnace-pressure control.

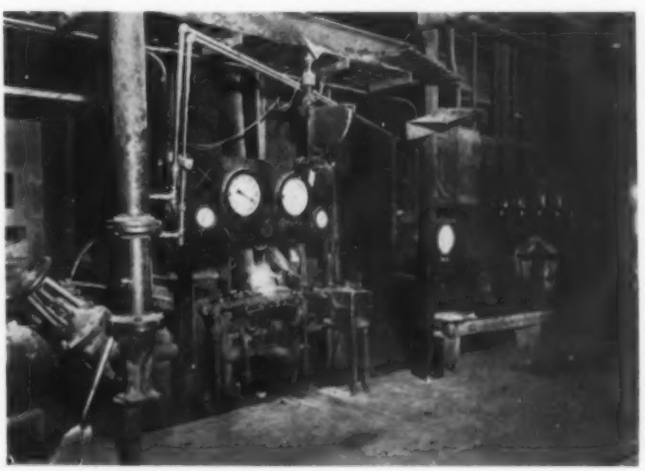
No. 2 open hearth was built in 1915 and has ten furnaces. No. 21 furnace in this shop was completely rebuilt with double front flush and bifurcated spouts and taps 300 tons per heat. No. 22 furnace was modified to have double front flush and bifurcated spouts and taps 280 tons per heat. The other eight furnaces tap 140 tons per heat. Before the installation of the new controls, the equipment on the furnaces consisted of liquid-fuel recorder-controllers, coke-gas meters, and two steam gages. All of the furnaces had furnace pressure control and none of them had forced-air fans. See Figure 1.

No. 3 open hearth was put into operation in 1936 and has six furnaces that tap 220 tons per heat. These furnaces were equipped with modern controls of that time, which consisted of a four-record potentiometer for measuring the temperature of the flue gases, roof-temperature control, combustion-air flow meter, regulator for fuel-oil temperature, indicating gages for furnace pressure and flue draft, atomization-steam flow meters, gas-flow meters, fuel-flow meters and furnace-pressure regulators. Air-fuel ratio regulator was installed on one furnace when the shop was built and on the other five at a later date. This control had to be taken out of service when pitch was used in place of Bunker "C" fuel oil because of trouble experienced in maintaining the liquid-fuel measuring equipment when using pitch. None of the thirty furnaces were equipped with automatic reversal systems. See Figure 2.

The new combustion-control panel boards measure and control the following items: combustion air, furnace pressure, atomization-steam pressure, (six furnaces equipped with atomization-steam flow recorder-controllers) and liquid fuel. Four record potentiometers record either the flue-gas temperatures or the checker temperatures. Ten furnaces are equipped with checker-temperature recorders, and twenty have flue-gas temperature recorders. In the near future eight more furnaces will be equipped with checker-temperature recorders. Checker-temperature recorders are of much more value than sewer temperature, but the cost of installation and maintenance is considerably higher. No. 3 open hearth furnaces are equipped with roof-temperature recorders. The panel boards are also equipped with recording coke-gas meters. All the controls are of the pneumatic type. This type of control was used because of the freedom from fire hazard and the cleanliness of air over hydraulic controls that used oil.

Two timers that can be varied from 0 to 30 minutes control the reversing cycle. The time-cycle reversal was chosen because of the difficulty of maintaining the

Figure 1 — Originally, controls on the open hearth furnace were few and simple.



temperature-measuring equipment to have temperature reversal based on checker temperature. With two timers and the checker or sewer-temperature recorder, the furnace can be kept in balance temperature-wise with few adjustments of the timers. Once the temperatures of the furnace are balanced and the time of reversal evenly adjusted on each end, the temperatures will stay balanced until making up the bottom or charging causes the furnace to get out of balance. When one of the timers "makes," it sets into action the necessary electrical equipment to start a 250-volt d-c reversing mechanism. To this reversing mechanism is chained a rotary cam switch which dictates four-way solenoid valves if they are to be energized or not, and stops the reversing mechanism at the desired place. At the instant of reversal, the energized solenoid valves on the "on" end are de-energized except for the steam which is kept until the reversal is completed to assure a complete purging of the liquid fuel from the burner. The de-energizing of the "on" end solenoid valves bleeds off the air-pressure loading on the diaphragm-type liquid-fuel and coke-oven gas reversal valves, allowing them to close and shut off the fuel. The reversing mechanism rotates until the reversing damper valves in the sewers are positioned and is stopped by the limit switch in the rotary cam switch. The instant the reversing mechanism is stopped, the switches controlling the solenoids on the fuel, gas and steam on the opposite end are made in the rotary cam switch. The energizing of these solenoid valves loads the diaphragm reversing valves with air pressure causing them to open. This puts liquid fuel, coke-oven gas, and steam on the other end of the furnace. The complete cycle from fuel "off" until fuel "on" takes about eight seconds. A selector switch is provided, so that the operator can operate the reversing cycle at will by turning the selector switch to manual, and turning a pistol-grip switch to the end on which he wants fuel. This is used when the furnace is being made up and charged. After the furnace is charged, the selector switch is turned to automatic and the furnace is reversed by the timers. A push-button switch is also provided so that the first helper can take the fuel "off" the furnace quickly if necessary.

Before automatic reversal was installed on our furnaces, it took the first helper an average of 15 to 20 seconds to completely reverse the furnace. He had to turn off his fuel, open up the steam valve on the opposite end, throw a switch which started the reversing mechanism, watch the "telltale" and stop the reversing mechanism when the dampers were positioned, then close down the steam valve on the "off" end and turn on his fuel. If coke-oven gas were being used on the furnace, he also had to throw a three-way cock in the gas line. Now, with automatic reversal, the complete cycle is accomplished in eight seconds without any effort necessary on the part of the first helper. Regular reversals were also dependent on the first helper's presence at the necessary time. If he were behind the furnace digging out the flush hole, the furnace was not reversed and, of course, there was always the man who just forgot to reverse the furnace on time. The elimination of these variables by the installation of automatic reversal allows higher fuel rates without undue overheating of one end of the furnace; keeps the fuel off the furnace less time by a quicker reversal, with resulting less cooling of the bath; keeps the furnace temperatures in balance, with the result that both ends work evenly; and gives the first helper more freedom to watch the furnace, flush, and work his heat. All these items help to keep the furnace at peak operating temperature without undue damage to the brickwork.

The increase in production that will be shown on the following charts cannot all be contributed to the installation of combustion controls and automatic reversal; but these have contributed considerably to the increase. In No. 3 open hearth, along with the installation of the panel boards, front flushing was introduced on all the furnaces. Since most of the data to be given deals with No. 3 open hearth, some of the credit for the increase in production and decrease in fuel consumption must be given to the front flush. Front flushing gives a better, faster flush that is easier to control, eliminates considerable delays due to backwall repairs, and keeps the first helper in front of the furnace where he can watch his heat. A summary of the operation of No. 3 open hearth from 1946 to 1950 is given in Table I.

Figure 2 — These controls were modern when No. 3 open hearth was put into operation in 1936.

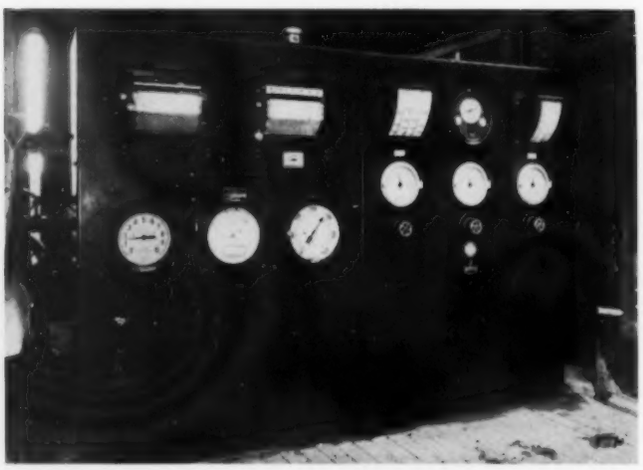


Figure 3 — The furnace control now includes such features as checker temperature recorders and automatic reversal.

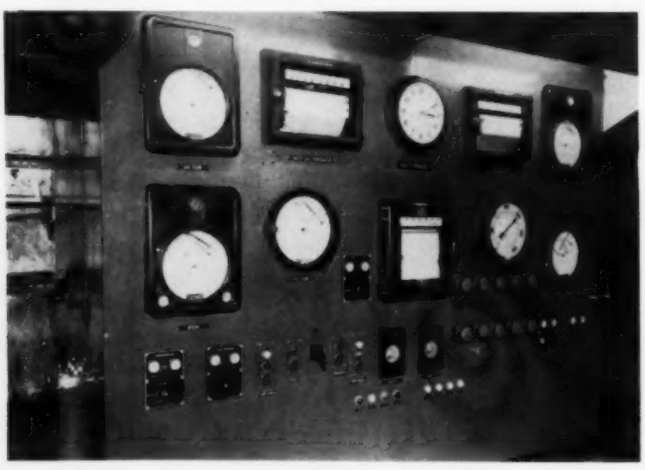


TABLE I

OPERATION NO. 3 OPEN HEARTH — 1946–1950

	Total tons	Per cent hot metal	Average tons per heat	Tons per hr	Cold chg time, hr-min	tap to tap, hr-min	Charge to tap, hr-min	Million Btu/ton
1946	607138	52.5	200.6	17.3	2:18	11:36	10:21	4.06
1947	791502	54.2	199.9	17.1	2:20	11:43	10:35	4.4
1948	875979	50.5	203.8	18.6	2:26	10:58	9:48	3.7
1949	847434	49.7	218.8	19.7	2:29	11:06	9:52	3.24
1950	984663	49.8	217.6	20.7	2:17	10:30	9:20	3.19

This chart shows that the tons-per-hour figure has increased from 17.3 in 1946 to 20.7 in 1950. The average tons-per-heat tapped increased from 200.6 tons in 1946 to 218 tons in 1950. The appreciable increase in the tons-per-hour in 1948 and 1949 can be partly attributed to the increase in size of the heats. The Btu per ton figure decreased from a maximum of 4.4 million in 1947 to a low of 3.19 million in 1950, with a decrease of 0.5 million Btu per ton in 1949 when the controls were installed. The tons per hour figure was higher in 1950 than in 1949, and the Btu per ton lower with no physical improvement to the furnaces. The per cent of hot metal remained the same for both years and the cold-charging time approximately the same. The average weight per heat was the same in 1949 and 1950. The increased tonnage and the lower Btu per ton rate was brought about by the combustion controls and automatic reversal standardizing the operation of the furnaces.

TABLE II

OPERATION NO. 3 OPEN HEARTH — YEAR 1949

	Total oper hrs	Oper hrs with panel board	Per cent oper hrs with panel board	Cold chg time, hr-min	Per cent hot metal	Tons per hr	Tap to tap, hr-min	Charge to tap, hr-min	Million Btu/ton
January	4152	0	0	1:59	58.8	18.5	11:01	9:37	3.49
February	3724	192	5.1	1:59	55.93	19.2	11:05	10:01	3.57
March	4308	960	22.3	2:07	53.4	20.2	10:54	9:42	3.28
April	3936	2352	60.0	2:00	52.9	20.7	10:42	9:35	3.30
May	3930	2938	75.0	2:25	51.2	19.9	11:08	9:59	3.14
June	4184	4184	100	2:53	45.8	19.3	11:20	9:59	3.12
July	3314	3314	100	2:15	50.9	19.3	11:23	10:18	3.15
August	4419	4419	100	2:54	43.3	19.2	11:20	10:01	3.14
September	3505	3505	100	3:05	44.3	19.4	11:21	10:06	3.20
October					STRIKE				
November	3218	3218	100	2:56	44.6	18.7	11:37	10:13	3.51
December	4317	4317	100	2:49	45.2	20.9	10:33	9:25	3.06
Average	43007	29399	68.4	2:29	49.7	19.7	11:06	9:52	3.24

Figure 4 — Automatic furnace reversal takes less time than manual operation.

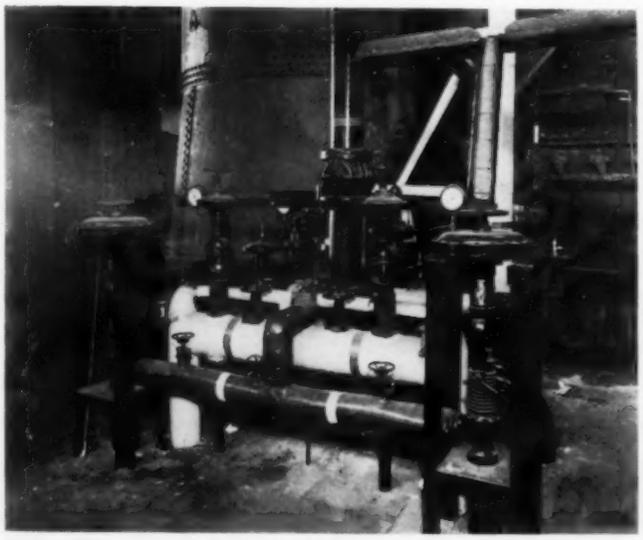
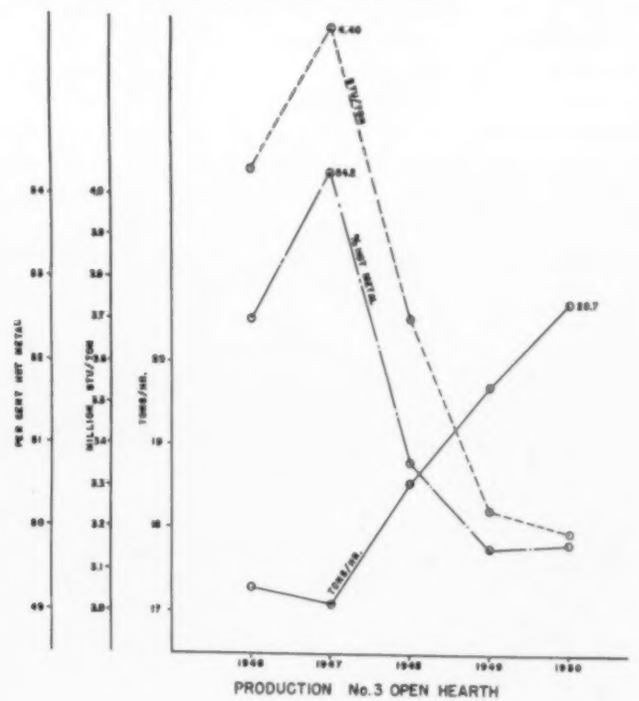


Figure 5 — Production from No. 3 open hearth over a four year period is given in this chart.



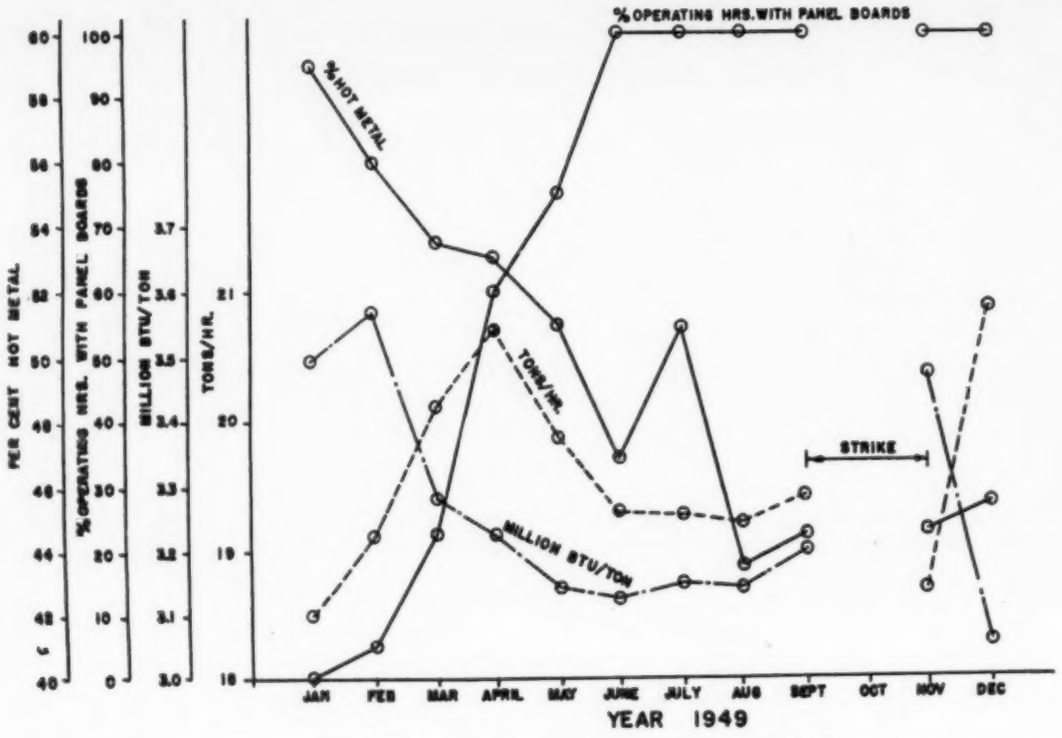


Figure 6 — During and after the installation of the automatic control, fuel requirements decreased.

naces, and the elimination of the human variables which resulted in the more efficient operation of the furnaces.

Table II shows the operation of No. 3 open hearth for the year 1949 when the controls were installed. The installation started in February and was completed in May. June, 1949 was the first month with all the panels in operation during a complete month.

The tons per hour figure for the first months with all the controls in operation, was not as good as for the month of April when 60 per cent of the operating hours were with automatic controls. However, it was as good as, or better than the first two months of the year when none of the panel boards were in operation. The per cent of hot metal available decreased during these months, which probably explains the lower tons per hour rate. The fuel used to make a ton of steel was much less after the installation of the controls than before and continued to stay down below the first few months even though the tons per hour rate was lower.

In 1950, nine out of the fourteen furnaces at No. 1 open hearth broke their previous tonnage records and the total shop record was also broken. No. 2 open hearth had eight furnaces break their tonnage record and a new total tonnage record was made. All furnaces at No. 3 open hearth broke their yearly tonnage record in 1950, of course, the total shop tonnage record was broken. The total plant in the year 1950 produced 3,600,168 tons of steel, compared with 3,075,358 tons in 1949, an increase of 11.7 per cent. As was pointed out early in the paper all of this increase in production cannot be contributed to the installation of combustion controls and automatic reversal, but they certainly were contributing factors.

A furnace does not necessarily produce more steel and use less fuel when combustion controls and automatic reversal are installed. They only serve as a guide and to furnish a record of the conditions of the furnace, so they may be analyzed to see what is happening. If a furnace is not slurried properly and the infiltration is high, the resulting low air preheat will keep it from operating properly. The controls cannot correct this condition, but they can tell that it exists. If the analysis of the waste gases show that the oxygen in the downtakes is high, and the combustion-air meter is showing the correct amount, then the additional air must be coming from leakage. The checker-temperature recorder can also tell the same thing by showing an unusually low checker temperature. Care must be taken that all controls are functioning properly at all times and that they are accurate; otherwise, they are more of a liability than an asset. If the first helper uses controls that are not operating properly and the furnace consequently suffers, he will lose faith in the instruments, and the time and effort expended in their installation will have been wasted. In most cases, it is difficult to instill in the first helper the necessary confidence in the controls, and his confidence will be easily destroyed if they do not function properly.

An open hearth furnace is a complex piece of equipment, with so many variables that it is almost impossible to single out any one factor that may be wrong and correct it, without a continuous accurate record of what has happened to the furnace. The more variables that can be taken out of the operation of an open hearth furnace, the better chance there is to evaluate those that remain and find out what causes it to slow down or operate well, so that other furnaces may be adjusted accordingly.

The installation of combustion controls and automatic reversal on a furnace is no cure-all, but a means to make a furnace operate more efficiently when all other ills have been corrected. But everything being equal, combustion controls and automatic reversal will help a furnace to produce more steel and use less fuel.

ASSOCIATION OF IRON AND STEEL ENGINEERS

1951 Annual Convention

HOTEL SHERMAN

CHICAGO, ILL.

OCTOBER 1, 2, 3 and 4

Kaufmann & Fabry Photos

Program

1951 AISE CONVENTION
HOTEL SHERMAN
CHICAGO, ILL.

Monday, October 1

9:00 am — REGISTRATION — First Floor Lounge

9:00 am — LADIES REGISTRATION AND HEADQUARTERS — Mezzanine Floor

A program of ladies activities will be available upon registration.

9:30 am — BUSINESS MEETING — Louis XIV Room Conducted by I. N. Tull.

10:00 am — ELECTRICAL SESSION — Louis XIV Room

Chairmen: R. W. Graham, Superintendent Electrical Department, Bethlehem Steel Co., Lackawanna, N. Y.
W. J. Tunny, Superintendent Electrical Maintenance, Youngstown Sheet and Tube Co., East Chicago, Ind.

"Multiple Generators for Processing Lines," by E. E. Vonada, Application Engineer, Reliance Electric and Engineering Co., Cleveland, Ohio.

"Increased Interrupting Capacity in Fuses," by John C. Lebens, Chief Engineer, Bussmann Manufacturing Co., St. Louis, Mo.

"Has Industrial Tractor Design Kept Pace with Steel Mill Operating Requirements?" by Carleton Lord, Material Handling Engineer, United States Steel Co., Pittsburgh, Pa.

10:00 am — COMBUSTION SESSION — Crystal Room

Chairmen: C. W. Bruce, Assistant Chief Engineer, Republic Steel Corp., South Chicago, Ill.
E. A. Hawk, Fuel Engineer, Tennessee Coal, Iron & Railroad Co., Ensley, Ala.

"Combustion Gas Turbines and the Steel Industry," by W. B. Wilson, Application Engineer, Industrial Power Div., General Electric Company, Schenectady, N. Y.

"Viscosity Control of Fuel Oil for Open Hearths," by Harvey Krouse, Field Engineer, Fischer and Porter Co., Pittsburgh, Pa.

2:00 pm — MECHANICAL SESSION — Crystal Room

Chairmen: L. F. Coffin, Superintendent Mechanical Dept., Bethlehem Steel Co., Sparrows Point, Md.
James J. Healy, Project Engineer, Armco Steel Corp., Middletown, Ohio.

"Metallurgical Tips for the Maintenance Man," by Michael V. Herasimchuk, Maintenance Metallurgist, Bethlehem Steel Co., Bethlehem, Pa.

"Accurate Steel Mill Weighing," by K. A. Blom, Corporation Weighing Supervisor, Republic Steel Corp., Cleveland, Ohio.

"Crane Runway Maintenance," by H. Russell Knust, Assistant Superintendent, Mechanical Department, Bethlehem Steel Co., Sparrows Point, Md.

2:00 pm — OPERATING PRACTICE SESSION — Louis XIV Room

Chairmen: Arthur K. Blough, Superintendent No. 2 and No. 3 Melt Shops, Republic Steel Corp., Canton, Ohio.
W. J. Reilly, Manager, Steel Mill, Ford Motor Co., River Rouge, Mich.

"Production Characteristics of the Open Hearth," by H. F. Lesso, Open Hearth Control Metallurgist, Great Lakes Steel Corp., Ecorse, Mich.

"A Comparison of Electric Furnace and Open Hearth Economics," by H. W. McQuaid, Consulting Metallurgical Engineer, Cleveland, Ohio.

"Heat Relief in Hot Industries," by B. R. Small, Staff Engineer, Mechanical Engineering Dept., Aluminum Co. of America, Pittsburgh, Pa.

Tuesday, October 2

9:00 am — ELECTRICAL SESSION — Louis XIV Room

Chairmen: James D. O'Roark, Electrical Superintendent, Weirton Steel Co., Weirton, W. Va.
C. G. Dimitt, Supervisor Design Engineering — Electrical, United States Steel Co., South Chicago, Ill.

"Coal and Ore Bridges," by E. L. Blankenbeker, Electrical Engineer, Heyl & Patterson, Inc., Pittsburgh, Pa.

"Modern A-C — D-C Crane Control for Steel Plants," by W. R. Wickerham and G. E. Mathias, Control Engineering Department, Westinghouse Electric Corp., Buffalo, N. Y.

"Crane Wheel Tread Contours," by John J. Stolz, Chief Engineer, The Tool Steel Gear & Pinion Co., Cincinnati, Ohio.

9:00 am — ROLLING MILL SESSION — Crystal Room

Chairmen: Wade F. Hoffman, Superintendent Roll Department, Jones & Laughlin Steel Corp., Aliquippa, Pa.
Alex Montgomery, Jr., Assistant General Superintendent, United States Steel Co., Duquesne, Pa.

"Roll Turning with Tracer Controlled Lathe," by Frank F. Zipf, Superintendent Roll Department, Bethlehem Steel Co., Johnstown, Pa.

"The United-Rendleman Rod Mill," by Norman Rendleman, Special Consultant, United Engineering & Foundry Co., Pittsburgh, Pa.

"Operation of a 12-In. Continuous Bar Mill," by A. H. Griffiths, Superintendent of Rolling Mills, Sheffield Steel Corp., Kansas City, Mo.

1:00 pm — INSPECTION TRIP — Gary Sheet & Tin Mill, United States Steel Co., Gary, Ind.

6:00 pm — OLD TIMERS' DINNER — Louis XIV Room

Wednesday, October 3

9:00 am — LUBRICATION SESSION — Crystal Room

Chairmen: Andrew Cichelli, Lubricating Engineer, Bethlehem Steel Co. Sparrows Point, Md.
Frank L. Gray, Lubrication Engineer, United States Steel Co., Gary Works, Gary, Ind.

"Lubrication of Wire Rope," by C. H. Layton, Assistant Chief Rope Engineer, Hazard Wire Rope Div. & American Cable Div., American Chain & Cable Co., Inc., Wilkes-Barre, Pa.

"Quality Control of Lubricants," by Carlyle R. Burton, Superintendent of Maintenance, Hibbing-Chisholm District, Oliver Iron Mining Co., Hibbing, Minn.

"Spray Lubrication of Open Gears," by Joseph A. Rigby, Vice-President, Engineering — Sales, The Brooks Oil Co., Pittsburgh, Pa.

9:00 am — COMBUSTION SESSION — Louis XIV Room

Chairmen: G. J. Gockstetter, District Combustion Engineer, Republic Steel Corp., Chicago, Ill.
R. A. Lambert, Superintendent Steam and Combustion, Jones & Laughlin Steel Corp., Pittsburgh, Pa.

"A New Method of Annealing Coils," by Lee Wilson, Lee Wilson Engineering Co., Inc., Cleveland, Ohio.

"High Temperature — High Speed Heating for Steel Rounds," by A. F. Kritscher, Development Engineer, National Tube Co., Pittsburgh, Pa.

"Operative Results of One-way Fired Recuperative Soaking Pits," by Jas. C. Stamm, Jr., Field Engineer, Fuel Department and E. H. Cauger, Chief Combustion Engineer, Wheeling Steel Corp., Steubenville, Ohio.

2:00 pm — GENERAL SESSION — Ball Room

Chairman: I. N. Tull, Electrical Superintendent, Republic Steel Corp. Cleveland, Ohio.

An address by H. W. Johnson, Vice President, Inland Steel Co., Chicago, Ill.

3:00 pm — STANDARDIZATION SESSION — Louis XIV Room

Chairman: Leo J. Gould, Chief Engineer of Construction, Bethlehem Steel Co., Bethlehem, Pa.

"Report of Activities of AISE Standardization Committee — 1951," by L. J. Gould, Chairman, AISE Standardization Committee.

"Carbon Brush Size and Shunt Standard — Final Report," by E. L. Anderson, Chairman, AISE Carbon Brush Standardization Committee.

"A Mill Motor Brake Standard — Final Report," by V. E. Schlossberg, Chairman, Mill Motor Brake Standardization Committee.

"Wiring Standard — Progress Report," by J. E. Bodoh and C. G. Dimitt, Chairmen, Wiring Standards Committee.

"American Recommended Practice of Industrial Lighting A-11," by J. J. Booth, Chairman, Steel Mill Lighting Committee.

"Development of Steel Plant Air Filter Data — Initial Report," by A. H. Arbogast, Chairman, Steel Plant Air Filter Committee.

3:00 pm — OPERATING PRACTICE SESSION — Crystal Room

Chairmen: A. F. Kritscher, Development Engineer, National Tube Co. Pittsburgh, Pa.
Paul E. Thomas, Assistant General Superintendent, United States Steel Co., Gary, Ind.

"Latest Developments in Extrusion of Metals," by Erwin Loewy, President, Loewy Rolling Mill Division, and Hydropress, Inc., New York, N. Y.

"Phosphate Coatings as Lubricants in the Severe Cold-Forming of Metals,"
Part I — General Description, by S. Spring, Group Leader, Research and Development Div., Pennsylvania Salt Manufacturing Co., Philadelphia, Pa.
Part II — Application, by Dr. Ludwig K. Schuster, Chief Chemist, Heintz Manufacturing Co., Philadelphia, Pa.

7:30 pm — FORMAL DINNER AND DANCE — Grand Ball Room — Hotel Sherman

Thursday, October 4

9:00 am — ELECTRICAL SESSION — Crystal Room

Chairmen: Malcolm B. Antrim, Superintendent Electrical Maintenance, Lukens Steel Co., Coatesville, Pa.
W. A. Perry, Assistant General Superintendent, Service, Inland Steel Co., East Chicago, Ind.

"Rectifier Application for Steel Mill Drives," by George B. Scheer, Chief Consulting Electrical Engineer, Kaiser Engineers, Division of Kaiser Industries, Inc., Oakland, Calif.

"Control of Demand and Power Factor on Electric Arc Furnaces," by H. G. Heath, Electrical Engineer, Pittsburgh Lectromelt Furnace Corp., Pittsburgh, Pa.

"A-C Power Distribution in Steel Mills," by D. L. Beeman, Manager, Industrial Power Division, General Electric Co., Schenectady, N. Y.

9:00 am — OPERATING PRACTICE SESSION — Louis XIV Room

Chairmen: C. G. Hogberg, Assistant to Chairman, Blast Furnace Committee, United States Steel Co., Pittsburgh, Pa.
F. M. Rich, General Superintendent, Inland Steel Co. East Chicago, Ind.

"Cleaning of Industrial Gases," by Jay J. Seaver, Manager, Jay J. Seaver Engineers, Chicago, Ill.

"The Axial Compressor for Blast Furnace Blowing," by W. O. Lowell, Blower and Condenser Section, Mechanical Power Department, Allis-Chalmers Mfg. Co., Milwaukee, Wis.

"Blast Furnace Hearth Construction," by Owen Rice, Metallurgical Engineer, Freyn Engineering Co., Department of Koppers Co., Inc., Chicago, Ill.

2:00 pm — OPERATING PRACTICE SESSION — Louis XIV Room

Chairmen: John E. Angle, Assistant General Superintendent, Gary Sheet & Tin Mill, United States Steel Co., Gary, Ind.
Leonard Larson, Chief Engineer, Republic Steel Corp., Cleveland, Ohio.

"Rolling of Thin Strip," by M. D. Stone, Manager of Development, United Engineering & Foundry Co., Pittsburgh, Pa.

"Differential Thickness Coating on Electrolytic Tinplate," by S. S. Johnston, Technical Director, Electrolytic Dept., Weirton Steel Co., Weirton, W. Va.

"Flash Welding and High Speed Cold Reduction of Strip Steel for Tin Plate," by John Wargo, Assistant Tin Plate Metallurgist, and Ray C. Brunner, Development Engineer, Jones & Laughlin Steel Corp., Aliquippa, Pa.

2:00 pm — LUBRICATION SESSION — Crystal Room

Chairmen: D. N. Evans, Assistant Master Mechanic, Inland Steel Co., East Chicago, Ind.
D. E. Whitehead, General Lubrication Engineer, Crucible Steel Co. of America, Pittsburgh, Pa.

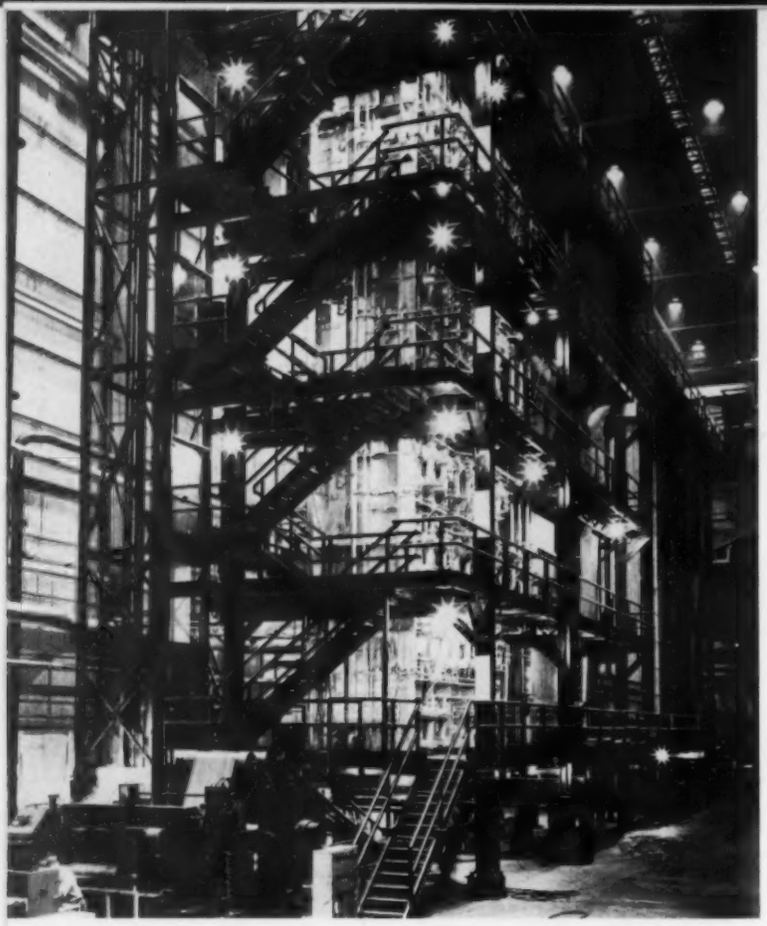
"The Application of Bentone Lubricants to the Steel Industry," by D. H. Compondu, Product Engineer, The Warren Refining & Chemical Co., Cleveland, Ohio.

"Standardization in the Lubrication Department," by J. D. Lykins, Chief Lubrication Engineer, Wheeling Steel Corp., Wheeling, W. Va.

"Reconditioning Air Filter Oils," by George Findlay, Lubrication Engineer, Republic Steel Corp., Buffalo, N. Y.

NOTICE!

The papers on this program, together with the convention discussions, will be published in future issues of the IRON AND STEEL ENGINEER



INSPECTION TRIP

TO

GARY SHEET AND TIN DIVISION

U. S. STEEL COMPANY

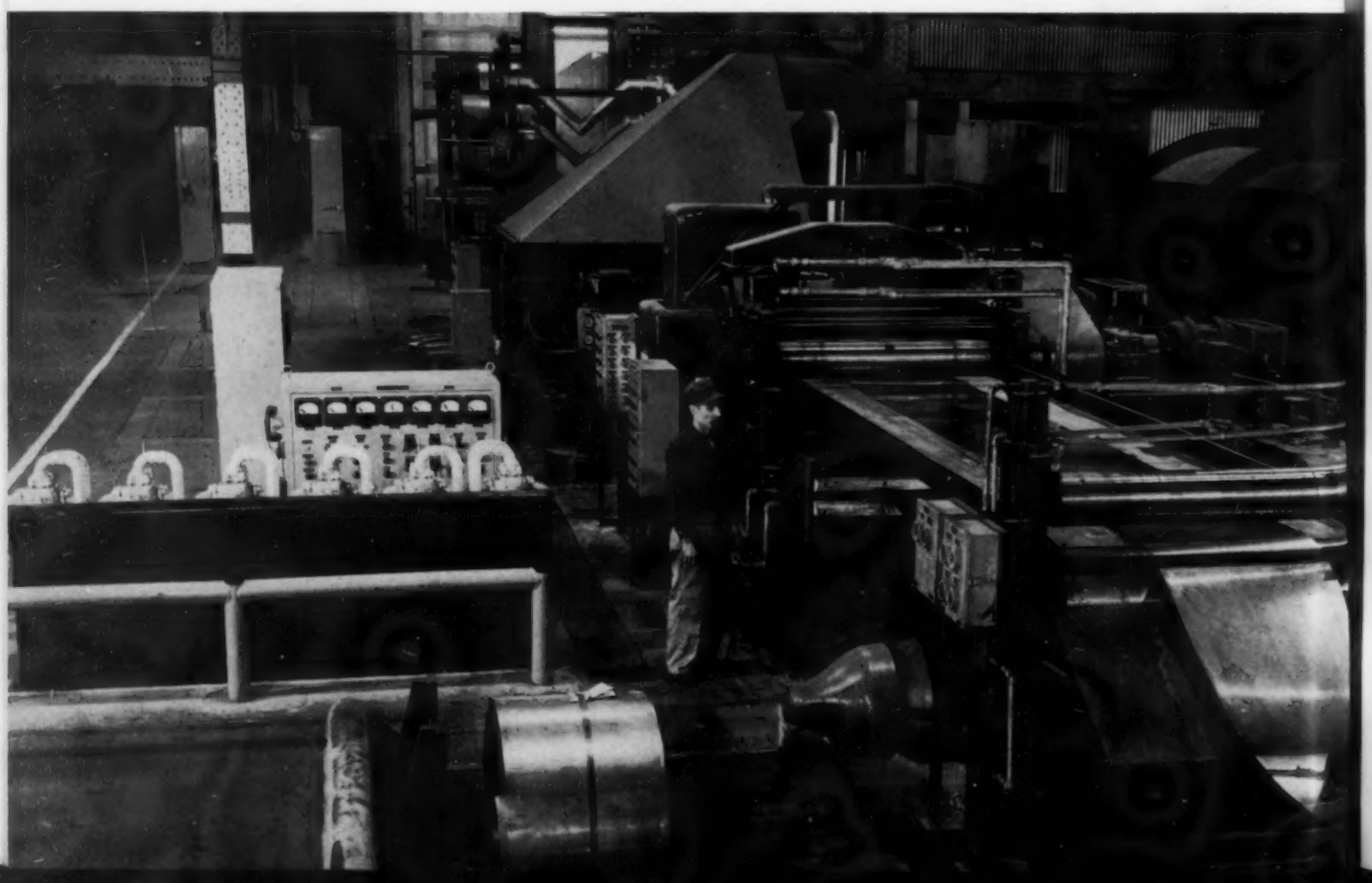
GARY, INDIANA

TUESDAY, OCTOBER 2, 1951

1:00 P. M.

Two units of unusual interest to be seen at Gary Sheet and Tin Mill are the continuous gas-electric annealing furnace shown above and the continuous galvanizing line pictured below.

Buses will leave La Salle Street entrance of Hotel Sherman at **1:00 p.m.** Tickets may be obtained at AISE Registration Desk.



NEW FACILITIES FOR STOCKING AND SHIPPING PIPE AT LORAIN WORKS

By C. CLARKE WALES
Chief Project Engineer
National Tube Co.
Lorain, Ohio

. . . . the new stocking and shipping facilities at Lorain have led to such efficient material handling that man-hours are only a fraction of those previously needed . . . .

▲ A DESCRIPTION of the new facilities provided by the construction program which has been in progress for the last few years at Lorain works of National Tube Co. has been presented in papers previously published in the Iron and Steel Engineer. These papers deal with new facilities which directly or indirectly have to do with the steelmaking processes of the plant or with the rolling and other pipemaking processes used in making and finishing of this steel into pipe to meet various customer requirements. This paper will describe the operation of the facilities which have been provided for the assembly, stocking and preparation for shipment to the customer of the final product.

Perhaps the best method of presenting this problem and its solution is to review briefly the general pipe mill layout of the plant as it existed before the new facilities were installed. Figure 1 shows this layout. Note that the butt weld pipe finishing facilities of Lorain works consists of seven bays running parallel in a north and south direction, flanked on the east by a coupling shop and on the west by a large galvanizing department. East of these, running parallel to these buildings, are seamless mills No. 1, 2 and 3 with their finishing floors, all delivering the finished pipe toward the south of this group of buildings. The buildings are joined in an east-west direction by a passageway to allow for the transfer of unfinished pipe from bay to bay where required, and along the south end of this group of buildings by a transfer bay for the transfer of finished pipe from shipping floor to shipping floor where required. The whole layout was conceived and developed between the late 1900's and 1930's and was designed to suit the finishing and delivery of pipe in all sizes from 26-in. seamless down to the smallest sizes of butt weld pipe, and for many years served its purpose well.

The use of pipe perhaps more than any other product of steel enters into every phase of our lives, both at home and in industry. Our mode of living has seen many complicated changes in recent years which have been reflected in the requirement for pipe in our homes, in office and industrial buildings, etc., and for the supply of water, oil and gas to these homes and to industry. These changes have brought about closer specifications and a considerable increase in the number of items manufactured in all sizes of pipe, and, at the same time, due to changes in marketing practices, an ever increasing demand for pipe in mixed carloads containing as many as 50 items and averaging 15 items in a car, in a wide range of sizes. The various size ranges of pipe, of course, are furnished to a wide range of customer requirements on different facilities located in different building areas. To stock this pipe as it is delivered from the finishing floors so that it may be assembled in carload lots to serve this modern customer requirement, there has been built at Lorain a new warehouse, containing many features which, while singly not entirely new, it is felt have been combined in a rather unusual manner and with outstanding results.

Figure 2 shows the rearrangement of the area immediately south of the finishing floors of the various mills and the location of the new warehouse, which has an operating capacity to store approximately 40,000 tons of pipe in sizes 4 in. and under, including in the neighborhood of 300 items, and a maximum storage capacity of 60,000 tons with all racks full.

The new No. 4 continuous seamless mill, designed to produce seamless pipe in sizes 4 in. and under, has been added to this group. A description of the processes used in this mill will be found in John L. Young's paper entitled "The Continuous Seamless Pipe Mill," April 1951 "Iron and Steel Engineer," and in a paper by Stevenson Findlater, published in the February 1947 "Iron and Steel Engineer."

Immediately south of the original butt mill finishing floors, a transit bay has been provided approximately 25 ft in width with narrow gage switch tracks into

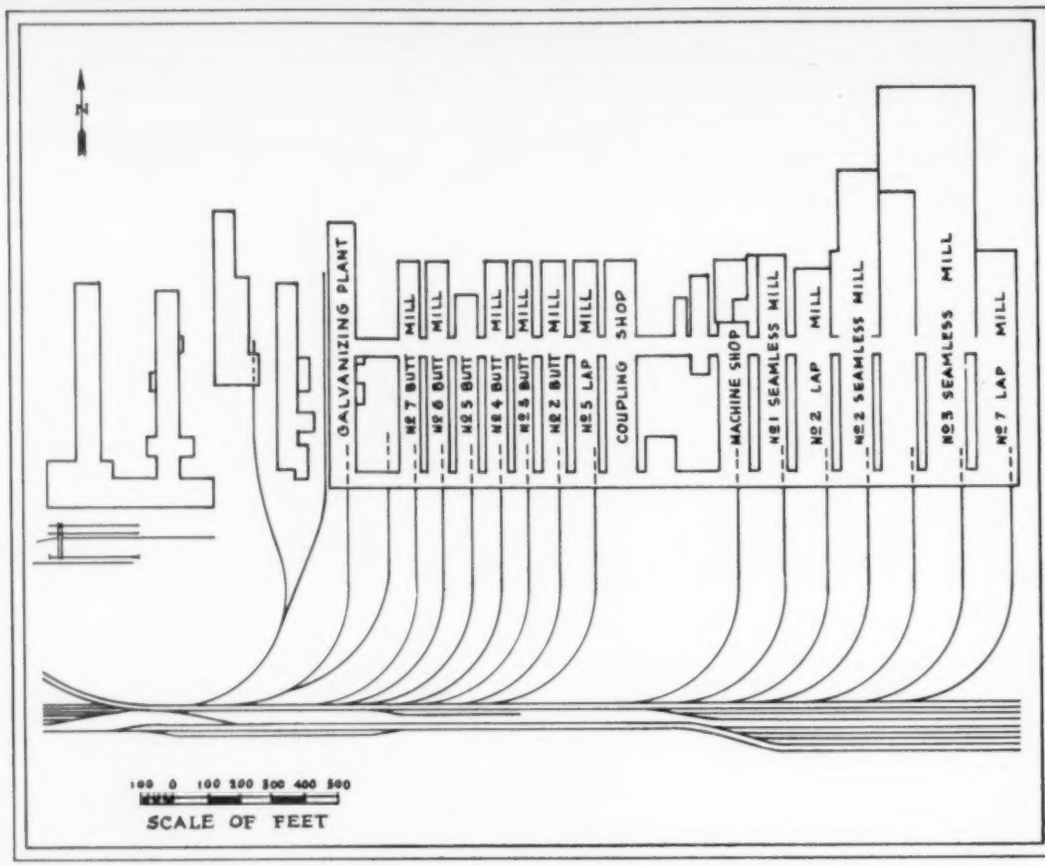


Figure 1 — Sketch shows layout of pipe mill area before the addition of the warehouse.

each of the butt mill finishing floors, and with connections to the finishing end of the new No. 4 seamless mill, on which narrow gage cars can be shifted from these various finishing floors to a common ladder track and from this ladder track to the warehouse stocking track running the length of the warehouse building. Thus, pipe finished in any mill can be spotted in the warehouse opposite any required stocking area. The main warehouse building is 1325 ft in length and 125 ft in width, thus making it possible to stock all pipe under

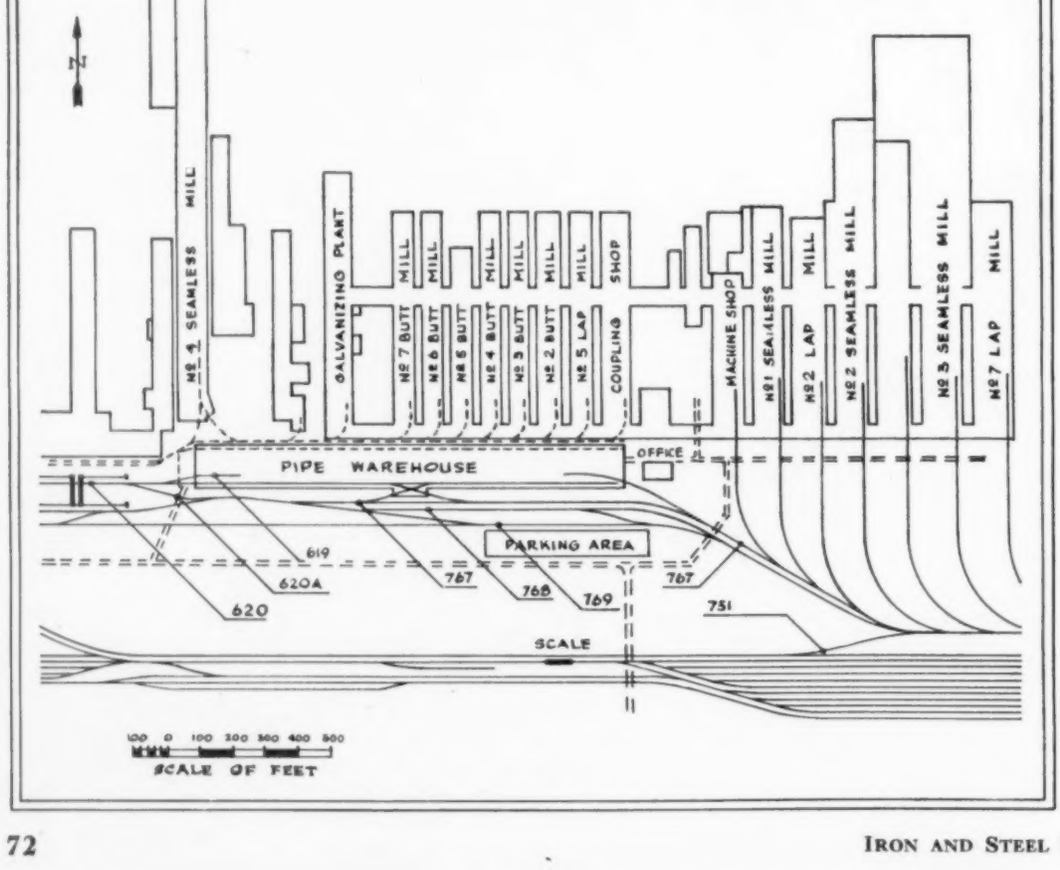


Figure 2 — Sketch shows layout of pipe mill area after addition of the warehouse.

one crane runway and also to maintain only one cycle of stock.

Figure 3 shows the stocking track with the various switch connections to the ladder track leading to the various finishing floors. This photograph also gives some idea of the extent and arrangement of racks for the storage of pipe in the warehouse. There is a total of approximately 500 racks for the storage of pipe.

These racks are of six standard designs, as shown in Figure 4. At the right are three sizes of permanent racks 5, 10 and 20 ft in width with the pipe posts cast in concrete, while at the left is shown two sizes of portable racks 2 ft-6 in. and 3 ft-6 in. in width which may be moved to various locations in the warehouse, or it is possible to change the width of the spacers to meet radical changes in the stocking pattern. A number of tally tables are provided at various intervals along the loading track which runs the length of the warehouse. These tables are used for tallying pipe before loading. At the right has been indicated the narrow gage cars used for the transportation of pipe from the mills and also portable shelf racks which are placed at convenient locations for stocking very small quantities of pipe required in connection with mixed carload shipment or for receiving pieces of pipe damaged from time to time in transportation or in handling in the warehouse.

This whole rack layout was based on an extended and detailed study of pipe market requirements, and, while this pattern of market requirements is continually changing, it has thus far been found necessary to make few changes in the rack pattern to meet variation in market pattern. In general, it will be noted that the larger racks are installed near to the stocking track, while the smaller racks shorter in height are placed closer to the shipping track. This design feature was adopted due to the fact that incoming pipe from the mills is handled in larger lifts while outgoing pipe is handled in smaller lifts.

The warehouse contains four 10-ton, electric overhead traveling 4-hook cranes with the cab mounted on the trolley. This design keeps the crane operator always over the load so that he has full vision of the lift during all stocking and loading operations. All storage racks are grouped and so lettered and numbered that they can be easily identified and records can be maintained of the location and quantity of all items of pipe in the warehouse at any one time.

The warehouse is operated by four stocking and shipping crews and divided into four areas of equal work so that all crews are equally busy at all times, and each crew is not required to be familiar with the stock in more than its own area.

Figure 5 shows a view of the standard gage loading track which runs the length of the south side of the warehouse. In general, it is customary to ship pipe with the larger items in size in the bottom of the car and the smaller items on the top. For this reason, the pipe is stocked with the larger items in the west end of the warehouse and the smaller items in the east end of the warehouse. Standard gage cars are assembled on tracks west of the warehouse by a diesel switching locomotive, and the cars proceed through the warehouse from west to east, receiving first the required preliminary blocking as they enter the warehouse and then the larger sizes of pipe of various grades down to the smaller sizes as the cars progress through the warehouse.

An elaborate signal system is provided to protect the loaders who work from the platform, shown at the left in Figure 5, when shifting cars. Cars are shifted every several hours, two, three or four cars at a time, as required. Blocking is completed and final preparation for shipment carried out at the east end of the warehouse before the cars are delivered to the yard, thus, up to 26 cars are available for loading at any one time on the main loading track, and all loading operations are carried out with a minimum of crane bridge travel. Auxiliary standard gage switch tracks are provided at each end of the warehouse for rearrangement of loads where required or special requirements that do not readily fit into this streamlined loading operation.

Truck doors and truck areas are provided at either end of the warehouse for assembly and handling of a reasonable amount of truck shipments. From time to time certain racks are assigned for the assembly of especially complicated carloads of pipe. In general, however, by far the larger portion of pipe is rolled by

Figure 3 — General view of pipe warehouse.

mill order to maintain a proper inventory balance in relation to current customer requirements.

Returning to Figure 2, which shows a schematic arrangement of the standard gage tracks used in connection with the handling of cars into and out of the warehouse. Track 620 is the receiving track on which the empty cars are received from the railroad. This track passes through an open crane yard 500 ft long and 100 ft wide in which is stocked a miscellaneous assortment of pipe larger than 4 in., which from time to time is required for shipment along with pipe 4 in. and under, stocked in the warehouse. This pipe is loaded as required in this yard as the cars pass through it on track 620. Occasionally a car is entirely loaded in this yard or in the warehouse on track 619, in which case it may be delivered onto track 620-A without passing through the warehouse. South of the warehouse are shown tracks 767, 768 and 769, which are used as set-off tracks either for loaded or empty cars as required, while tracks 767 and 768 east of the warehouse are the main delivery tracks for loaded cars being delivered to

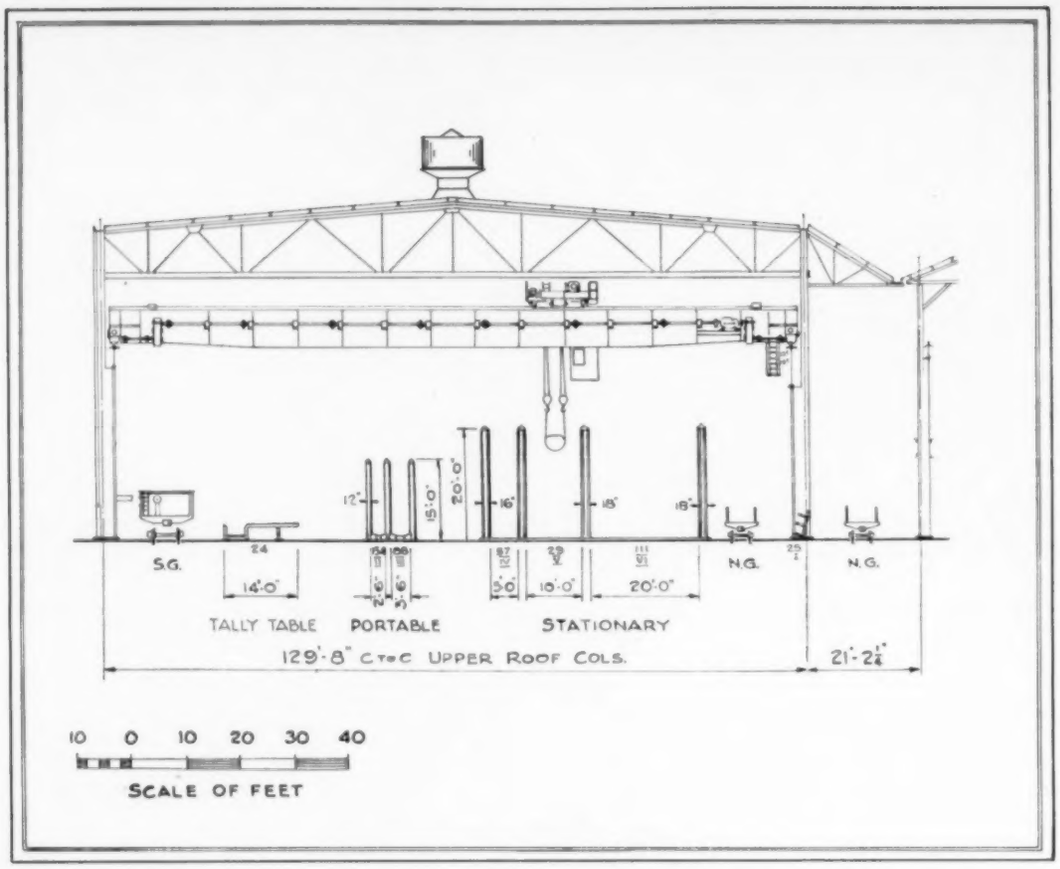


Figure 4 — Cross-section of the warehouse shows the various rack sizes.

the main scales and classification yards of the Lake Terminal Railroad.

Production planning and control for this whole operation is carried out from a new office building located immediately east of the warehouse and an operational field office located about midway in the length of the warehouse.

After considerable study of various methods, radiant heating from a concrete floor slab was finally adopted in the warehouse to provide principally for the protection of pipe stock. The black-pipe surfaces readily absorb heat radiated from the floor slab and reradiates it through the pipe stock. Pipe surfaces are in this way maintained at a higher temperature than the surrounding atmosphere, and surface corrosion is prevented as condensation of any moisture in the atmosphere does not occur. This radiant heating system, probably the most extensive of its type in the country, consists of approximately 25 miles of 1 in. black standard buttweld pipe, formed into sinuous coil patterns and laid in the concrete floor. The system is automatically controlled, to provide the desired atmospheric conditions and has performed with great efficiency since its installation.

Pipe shipped from the warehouse, practically all in mixed carload lots, has been handled and shipped over a monthly period at the average rate of 60 cars per 24-hour day by a normal crew consisting of 24 men per turn. All switching of cars in and out of the warehouse from the time the empties are received from the Lake Terminal Railroad until the loaded cars are delivered is accomplished by one 50-ton diesel electric locomotive. This locomotive, as well as the narrow gage system, is under warehouse supervision.

In addition to the railroad car shipments of pipe, this warehouse handles, with the assistance of one straddle truck and one fork truck, the making up and preparation for shipment of an average of 30 truck loads of pipe in 24 hours. Pipe is assembled on bolsters in the warehouse at a uniform pace over the whole 24-hour period and the bolsters are transported by straddle truck to a parking lot south of the warehouse. The handling of shipment by truck provides the usual problems brought about by inability to control the time of arrival of trucks. At certain times trucks may arrive at the rate of 10 per hour, while at other times there will be no truck arrivals for many hours. The combination of straddle truck and fork truck meet this fluctuation in loading and shipping rate in a very satisfactory manner, since the loads are prepared on bolsters ahead of time and can be placed on the trucks in a matter of minutes without interferring in any way with the normal operations of the warehouse.

Figure 5 — The standard gage loading track runs the length of the south side of the warehouse.

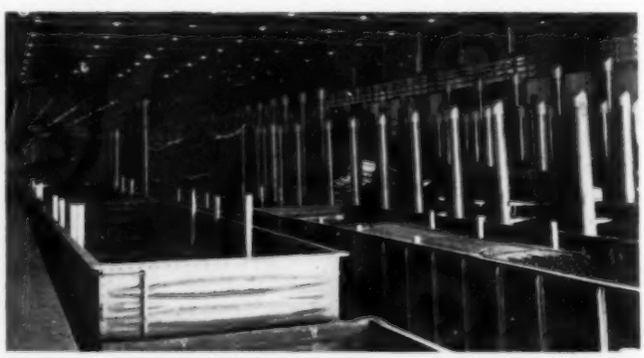


Figure 6 — View shows installation of radiant heating pipe coils in the warehouse.

The locker room facilities provided by the new construction program at Lorain have filtered air delivered into the room through the ceiling outlets. The air is allowed to escape from the room through the bottom of the lockers thus providing circulation within the lockers. This air is heated during the winter months to maintain a uniform temperature in the locker room. The floor of this room is covered with a special antiseptic flooring material.

DISCUSSION

PRESENTED BY

S. O. EVANS, Chief of Engineering Developments, Babcock & Wilcox Tube Co., Beaver Falls, Pa.

C. CLARKE WALES, Chief Project Engineer, National Tube Co., Lorain, Ohio.

FRANK SANFORD, Supervising Industrial Engineer, National Supply Co., Pittsburgh, Pa.

JOHN W. KIGHT, Spang-Chalfant Division of the National Supply Co., Ambridge, Pa.

GEORGE H. SHIVELEY, Superintendent Finishing Department, Spang-Chalfant Division of the National Supply Co., Ambridge, Pa.

JOHN L. YOUNG, Vice President - Chief Engineer, United States Steel Co., Pittsburgh, Pa.

P. L. WALTER, Superintendent Mechanical Department, Republic Steel Corp., Canton, Ohio.

S. O. Evans: I might say that the problems that we had encountered at the Babcock and Wilcox Co. are entirely different from those encountered in the Lorain works of National Tube Co. I say that with a note of envy because our operations are special, more in line with the operations in the Gary plant of National Tube Co., where the specifications with regard to length, wall, and analysis make it necessary to treat each order very specifically.

I noticed, in one of the illustrations, that there are separators in the racks. I would like to ask Mr. Wales how the specific quantities are picked out of the racks? That is, are they put in, in advance in the right quantities so that they are separated and can come out in the correct quantities for known orders, or how is the load picked out of the rack with the correct quantities in the lift?

I assume that there are crane followers. Do they climb up the racks or are there some special provisions for getting them to this height of twenty or twenty-five feet where they will need to make their next lift of tubes?

Finally, I would like to hear some further comments on the effectiveness of the radiant heating and the efficiency of this system.

C. Clarke Wales: The pipe is finished and delivered to the warehouse from the mill in lifts of the maximum size for convenient handling, but without regard to quantities required for a specific customer's order. Quantities are taken from the racks and counted out by single pieces or bundles as the case may be to make up these orders.

All the large racks are provided with permanent ladders mounted on the rack posts. For the small racks aluminum ladders have been provided for use where required.

Incidentally, I should mention particularly in the case of the larger racks, at least two racks are assigned to a given item of pipe so that one may be emptied while the other is being stocked, thus keeping all stock moving and reducing the tendency for stock in the bottom of the rack to become dead in the sense that it lays there over very long periods.

The radiant heating system has proven very effective and economical in operation, getting the heat under the piles of pipe where it is most effective in reducing condensation, and resulting surface deterioration of the pipe.

The radiant heating system is divided into four separate sections of equal size, each area being about half the length of the warehouse by half the stock area width, that is, the width of the building minus the width of the stocking and shipping track areas.

Thermostats are provided about midway in each section, located about 5 ft above the floor, and an outside thermostat is installed on the roof of the building to control the system automatically with regard to sudden changes in outside temperature conditions. Hot water is steam heated through heat exchangers. The maximum water temperature is controlled to 135 F maximum, floor temperature rarely exceeding 90 F. Steam consumption is considerably less than would be expected for similar results by other heating methods.

Frank Sanford: I would like to ask how many turns you operate your shipping department?

In the revision of the warehouse you showed the effect of the revised planning. What effective use did you make of the labor you had previously used? In other words, what was the increase in labor efficiency in the shipping department itself, particularly in the loading and preparing of the pipe for shipping?

C. Clarke Wales: I will answer the last question first. I do not have exact figures at hand with regard to labor saving, but I think it fair to say that between one quarter to one-sixth the labor is required to perform the same functions with the new facilities, the labor thus saved being used to fill other plant vacancies. With

regard to the first question, shipping from the warehouse is normally carried out on fifteen turns per week.

Frank Sanford: Does the same crew which handles the pipe coming from the furnaces in the narrow gage cars also unload the cars?

C. Clarke Wales: The same crew does both stocking and shipping.

John Kight: How many cranes do you have for each crew? Do you ship full carload lots from the mill, or is everything handled through the warehouse? Do the straddle trucks take the load to the over-the-road trucks direct for loading outside, or are the bolster loads returned to warehouse for loading by an overhead crane?

C. Clarke Wales: There are four 10-ton electric overhead traveling cranes in the warehouse and four crews, thus one crane per crew.

I am not clear on the second question with regard to full carload lots.

John Kight: When you have an order for a full carload, does that go through the warehouse or is it loaded directly off the mill?

C. Clarke Wales: Yes, full carloads are loaded from warehouse stock not direct from the finishing floor. There is often considerable advantage outweighing the extra handling cost in not having to coordinate mill schedules with shipping schedules. However, where required, pipe can be transferred direct to outgoing cars from the narrow gage in the warehouse.

John Kight: You said that you had straddle trucks and fork trucks to handle bolster loads for over-the-road trucks when they did not come in at the controlled rate into the loading platform. Those loads, I presume, are taken outside to get them out of the way. Are the bolster loads transferred to over-the-road trucks by means of overhead cranes or what are the means?

C. Clarke Wales: We use a heavy duty fork truck of a type equipped with standard road truck tires for loading the over-the-road trucks in or adjacent to the outside bolster parking area. Only occasionally in the case of an exceptionally difficult load is it necessary for the straddle truck to return the bolster to the warehouse for electric overhead traveling crane loading.

S. O. Evans: What do you do about closed top truck loading?

C. Clarke Wales: We have no closed top truck loading. All pipe is shipped in open top trucks. We did consider this possibility and laid out a C-hook for this work, but its use has not been required.

George H. Shiveley: You mentioned that you stock around forty to sixty thousand tons in your warehouse. What per cent of that is finished, ready for shipment? You had some stock in your warehouse that was unfinished pipe.

C. Clarke Wales: No, with a few possible exceptions, all the pipe in the warehouse is finished, ready for shipment to the customer.

George H. Shiveley: Is it completely assembled at the test bench marking?

C. Clarke Wales: If you mean by assembled counted for customer's orders, no. Pipe is delivered from the finishing floor to the warehouse in lifts which are convenient to handle, the amount per lift not being related to customers' orders. It is stocked and then doled out, so to speak, as the orders are assembled for shipment in the warehouse by the warehouse crews.

George H. Shiveley: How do you handle your outside inspection?

C. Clarke Wales: There is practically no outside inspection on butt weld pipe. Where required, this is done in the mill as the pipe is being processed, or on rare occasions the pipe is returned from the warehouse to the mill for this purpose.

George H. Shiveley: Do you have a stock inventory finished other than that as the pipe goes into the warehouse?

C. Clarke Wales: All finished pipe goes to the warehouse for stocking and shipping; where this has received or is to receive outside inspection the pipe is properly segregated and specially marked.

John L. Young: All pipe going into the pipe warehouse is standard merchant pipe. This pipe is brought from the various finishing floors into the warehouse by the narrow gage system. The pipe is then removed from the narrow gage cars into the storage racks, or it can be taken direct to the standard gage cars on the opposite sides of the bay, or to trailer trucks at either end of the warehouse.

P. L. Walter: I was interested in noting from Mr. Wales' paper the use of straddle trucks in the handling of pipe. In our particular steel plant operations, we are using straddle trucks for handling ingots, blooms, billets and slabs. Incidentally, those of us in maintenance have found considerable use for straddle trucks for handling maintenance materials such as lumber, pipe, steel and various spares. They have been a very handy unit for us and have saved us a lot of time and money.

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ASSOCIATION OF IRON AND STEEL ENGINEERS, 1010 EMPIRE BLDG., PITTSBURGH 22, PA.

REQUIREMENTS FOR A MODERN STEEL MILL POWER DISTRIBUTION SYSTEM

. . . . distribution lines can now be built which are practically trouble-free . . . . savings because of decreased maintenance costs will pay for these better lines . . . .

By F. H. WICKLINE
Construction Engineer — Electrical
National Tube Co.
Lorain, Ohio

▲A STUDY of the 60-cycle distribution system installed to serve the new Lorain mills reveals certain principles that are applicable to all mill distribution systems, and it shall be the purpose of this presentation to make illustrative use of the Lorain system in establishing the requirements for an adequate steel mill main distribution system.

To begin with, the designers of mill high voltage systems must strike a balance between installation cost and service continuity, as well as provide a physical system which is adaptable to future growth or rearrangement to keep pace with load growth over a long period of years. There are many factors to consider in reaching a decision on how great a capital investment may be justified in order to provide service continuity.

Such items as weather conditions and lightning have been with us for a long time, and much statistical information is available to guide the designer. The cost of protecting systems from these natural phenomena, the statistical frequency of such phenomena, and the cost in production losses resulting from line failure and emergency repair work, must be evaluated before a decision can be made. Unfortunately, the majority of steel mills are located in areas subjected to rough weather, and lightning conditions, so that adequate protection from natural hazards is a basic requirement.

One detriment to continuous line operation common to and inherent in all steel mills is conducting dusts. Dusts from blast furnaces, bessemer converters, open hearths, etc., are well known enemies of line maintenance personnel, and it requires carefully scheduled outages to clean and replace insulators to keep line failure and production loss to a minimum.

To further complicate this problem, no completely satisfactory method of cleaning insulators has been yet devised, so that after a few cleanings, the very important surface glaze has been damaged.

Aside from features designed to contribute to reliability of operation, much thought has to be given to physical location and arrangement of lines so as to not obstruct valuable land areas and thereby prevent future building. Power line relocation for site clearance becomes a tedious and expensive process when line outage has to be maintained at a minimum to prevent production loss. Intelligent planning with comprehensive long term plant expansion plans in mind, can do much to keep areas free from obstructing power lines. The personal safety of those whose responsibility it is to work with or around high voltage lines is of prime importance.

These preliminary comments have set forth briefly salient requirements for a modern steel mill distribution system.

In summary those requirements are as follows:

1. Proper balance between cost and reliability.
2. Freedom from failure due to mill dusts.
3. Adaptability to future growth and/or rearrangement.
4. Minimum of land surface interference.
5. Provision for personnel safety.

With these items in mind the new Lorain works 60-cycle distribution system will be discussed to illustrate one method by which these requirements have been met.

At the time that the major construction program was launched at Lorain, existing mills were served by a plant 25-cycle generation and distribution system which was loaded to capacity; therefore, any new facilities had to be served by either enlargement of existing 25-cycle generation and distribution systems, or by purchased power from the public utility 60-cycle system.

There are many tangible advantages over 25-cycle power to be gained by use of 60-cycle power, these being: (a) 60-cycle equipment is a production standard, is less expensive, and can be delivered more quickly; (b) it requires less space; and (c) instrumentation and control schemes, particularly those involving electronic components, are more highly developed for 60-cycle systems.

These advantages, plus the fact that the new mills would be separate from the old plant, and the fact that adequate 60-cycle public utility system capacity would be available, decided the issue in favor of 60-cycle power.

In selecting the most advantageous distribution

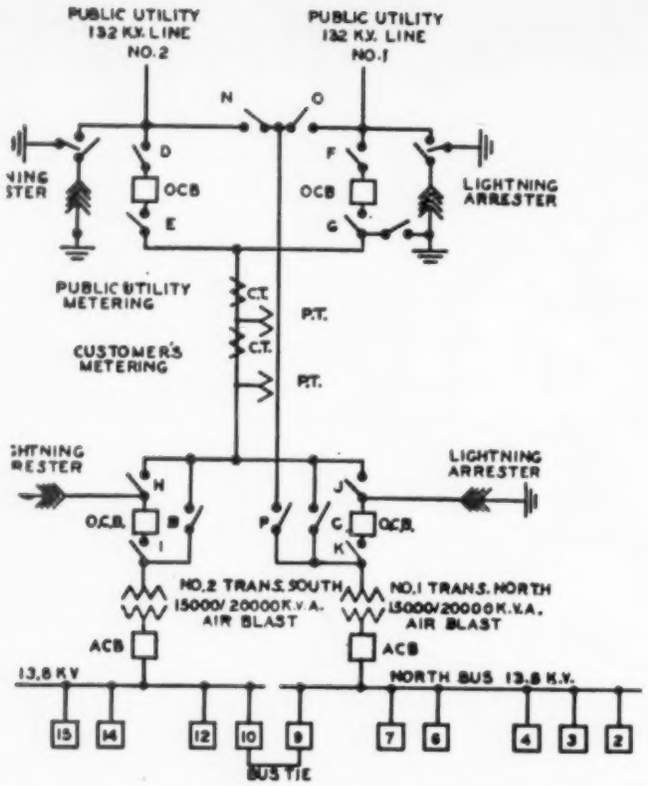


Figure 1 — Single line diagram of main sub-station.

voltage, an evaluation of copper cost, insulation cost, and cost of switching and transformer equipment had to be made. Overhead lines can be operated at higher voltage than underground cables, and at the optimum voltage from a copper cost — insulation cost standpoint, the least investment in copper can be obtained from overhead lines.

There are other factors, however, which limit the distribution system voltage to a value lower than that dictated by copper cost — insulation cost ratio. One factor is that great savings in step-down transformer capacity can be realized if the voltage selected is within the design voltage range of the large a-c drives to be supplied. Likewise, there is a point beyond which the voltage cannot be raised without the requirement for expensive outdoor type high voltage switching equipment, with necessary switchyard space at the load end of the lines.

The practical upper voltage limit for large a-c drives and for compact, metalclad, indoor type switchgear is 13.8 kv, and studies in this case showed that a very well balanced system would result if this value were chosen.

The selection of 13.8 kv as the distribution voltage brings the system well into the range of reliable cable application, making the consideration of an underground system possible.

It was pointed out in earlier paragraphs that prime requirements for a steel mill distribution system include minimum susceptibility to failures caused by mill dirt and weather phenomena, minimum land surface interference, and maximum personnel safety. Underground cable systems provide these features to a maximum degree.

The cost of underground systems for the particular case in point exceeds that for overhead lines of equivalent capacity by some 200 per cent, but it was felt that over the life of the system, the savings in maintenance and production loss resulting from the protection of the lines from mill dirt and weather phenomena would more than pay for the added investment, quite apart from the advantages from the standpoint of personnel safety. For these reasons, it was decided that the distribution system to serve the new mills was to be a 60-cycle underground cable system, operating at 13.8 kv.

Since the location of the various new mills had been determined, a site for the required main substation was chosen as near the load center of the overall mill area as possible, giving due consideration to future load areas. The required land area for the main substation was 250 ft × 389 ft, therefore, a site had to be chosen which would not interfere with future building areas, at the same time taking the location of the load center into account.

The main substation consists of two 132,000/13,800 kva oil filled transformers having a capacity of 15,000 kva without radiator fans, or 20,000 kva with fans, together with primary switching, lightning protective, and metering equipment and secondary switching equipment, arranged as shown in the schematic diagram in Figure 1.

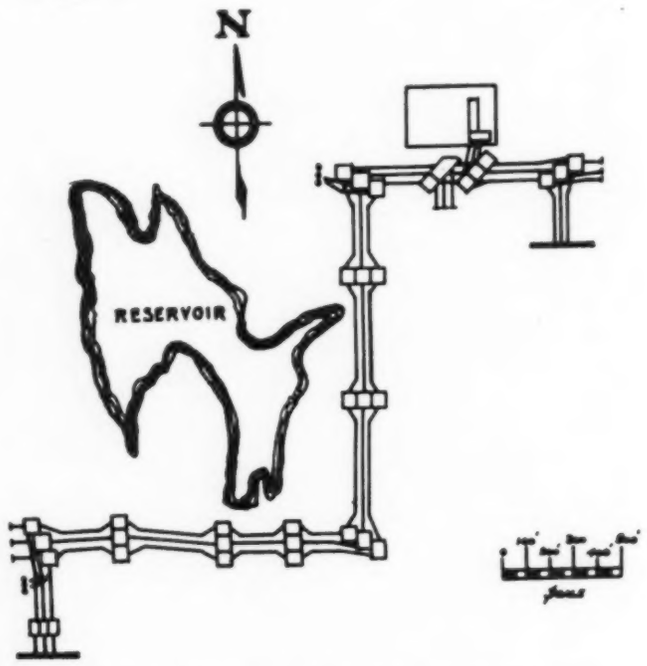


Figure 2 — Sketch shows general plan of duct lines.

One of the unique reliability features of this layout is the provision of a normally open 132-kv tie bus with air break switches arranged so as to permit closure of the incoming loop, and permit operation of the substation at full capacity with either or both of the loop breakers out of service; permit operation of the substation at full capacity with either or both transformer primary breakers out of service; and permit operation of the substation at half capacity with the metering bus de-energized.

With the 132-kv loop system in operation as at present, switches N and O both would be closed to complete the loop and allow inspection or maintenance

of either or both of the incoming line circuit breakers. With switches N and O closed, and either incoming breaker out of service, both transformers would be fed from the other incoming line breaker.

To completely de-energize the 132-kv bus for insulator cleaning or replacement, switches N, O, and P would be closed, and switches C, J, and K would be open, together with both incoming line and both transformer primary breakers, permitting the station to operate at half capacity on transformer No. 1.

No. 1 and No. 2 transformer primary breakers can be taken out of service by closing switches C and B respectively. Grounding switches are provided for grounding either side of the incoming loop, and the metering bus. In all cases, improper operation of the manually operated air break switches and grounding switches is prevented by an extensive key interlock system.

At the present time, the two incoming 132,000-volt lines are opposite sides of a loop in the public utility transmission system, but the plans are to change this at a later date to two parallel incoming lines. This may be done without making any changes in the switching, or in the relaying, except that the high speed directional overcurrent relays will be made operative. Automatic reclosing for the loop breakers is provided, with reclosure prevention if the two sides of the loop are out of phase.

The main power transformers are connected wye-wye with a delta tertiary winding. The primary neutrals are solidly grounded, and the secondary neutrals are grounded through an 8-ohm neutral resistor. Secondary ground fault current is limited to 1000 amp. These transformers are equipped with automatic load tap changers designed to vary the voltage of the primary from 90 to 110 per cent of normal voltage in sixteen steps of 1¼ per cent each.

There are air blast radiator fans controlled from oil temperature, which are capable of force cooling the transformers, allowing loads up to 20,000 kva without exceeding a temperature rise of 55 C.

The transformer secondaries are throat connected to outdoor type metalclad air breakers arranged in two bus sections with a tie bus between the two sections. This tie bus and its two breakers are temporary. At some future time when a third transformer is added, the tie bus will be removed and the breakers will become synchronizing bus reactor breakers.

The 13.8-kv protective relaying includes transformer differential, bus differential, inductive overcurrent, ground overcurrent, and pilot wire.

Permissive supervisory control of the 13.8 kv breakers is provided from the No. 4 seamless mill motor room by means of a coded impulse system. The supervisory control switches, and full telemetering equipment, are grouped on an upright operators panel equipped with mimic bus. A small electrically heated control house inside the substation enclosure houses the supervisory control and telemetering sending end equipment, together with the 132-kv carrier current relaying system transmitter-receiver. A circuit breaker test cabinet is also provided in the control house.

The basic station grounding system consists of nine elements, each made up of three 12 ft long, 1-in. copper-weld rods driven at each of the three corners of a 10-ft equilateral triangle, with each of the three rods in the element connected by means of a 500-mcm bare cable, clamped and phos-copper brazed to the rods.

The station ground-grid, to which all structure, all enclosures, and the transformer neutrals are connected, is connected to these basic elements.

By locating the basic elements in flue dust pockets just outside of the substation fill, ground resistance readings of 0.02 ohm were finally obtained.

All power circuits, together with the pilot wire cables, supervisory cable, and telemetering cables leave the main substation in underground ducts. The general routing of the underground duct system is shown in Figure 2. The portion actually installed represents the middle third of the ultimate system, inasmuch as a possible eastward extension could serve the pipe mill area, while a possible westward extension to the blast furnace area could serve that area, as well as tie into any future 60-cycle generating station which might develop. The section actually installed to serve the major project just completed, includes all necessary ducts for continuing the future east and west sections.

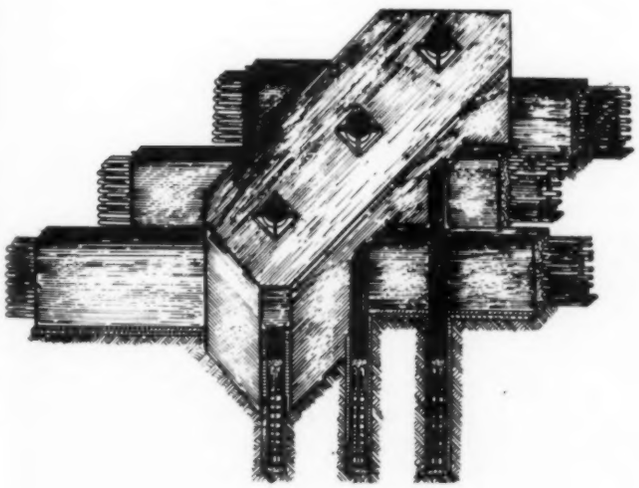
Duct line construction followed more or less standard procedure in applying non-metallic conduit and pre-cast spacers to build up the bank of ducts, these being enclosed in a poured concrete envelope. There are, however, several features which merit special consideration, since these features contribute to the economy of construction, and to the safety of operation.

In order to accommodate the large number of conduits in concrete and still not de-rate the cables excessively, three separate envelopes spaced two feet apart were used.

Before building up the conduit banks, a four inch concrete pad was laid down, which served as a bearing pad primarily, but incidentally as a leveling surface. After the banks were built up by use of pre-cast concrete spacers, they were tied to the pad by means of number nine steel wire, to prevent floating during the pouring of the envelope. Up to sixteen thousand linear feet of duct per day were laid by this procedure.

The envelopes were formed by the use of prefabricated modular form sections, keyed together by knock-out steel wedges. Due to the uniformity of envelope section,

Figure 3 — The typical manhole has three compartments.



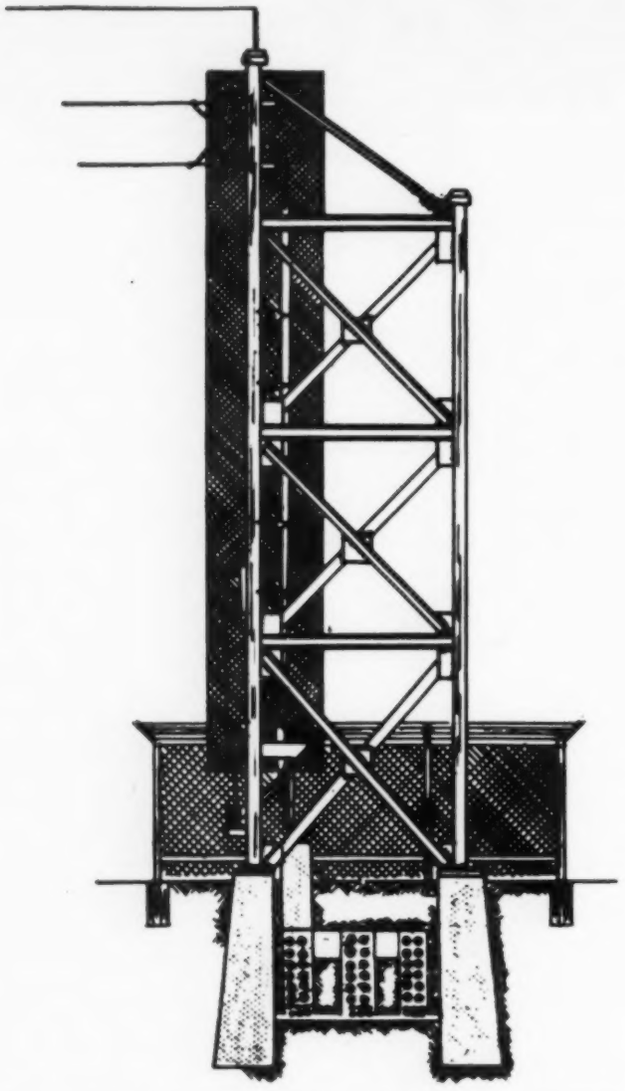


Figure 4 — Sketch shows typical transition from underground duct to overhead lines.

a relatively small investment in forms was required.

It is estimated that the application of modular form sections resulted in a saving of 25 per cent in the cost of formwork.

The aggregate used, contained washed pea gravel instead of slag in order that the heat insulating properties could be kept to a minimum and to eliminate voids. In compacting the concrete around the ducts, hand rodding was resorted to rather than mechanical vibrators due to the close spacing involved and the relatively fragile nature of the ducts. Light steel reinforcing was used in the envelopes with extra reinforcing where the ducts were laid in fill areas, under railroad tracks, steel storage areas, etc. In one area where the ducts were laid across a filled-in reservoir, the envelopes and the base pad were designed as self supporting concrete beams spanning the filled area.

In all cases, the duct lines slope toward a manhole, but no attempt was made to slope the entire system toward a central drainage point or to provide sewer taps which would keep the system drained. Sumps are provided in all manholes to facilitate pumping with portable equipment, and permanent float operated pumps are installed at all motor room duct entrances to take care of any drainage into the motor room basements.

Circuits are arranged so as to place each of the two or three feeders serving each individual mill in separate envelopes so that in case of trouble, all cables in any given envelope can be de-energized to allow work on that section without danger to personnel. Local plant safety requirements made it necessary to compartment all manholes inasmuch as it is not permitted that personnel may enter a manhole enclosing live cables. This means that all manholes are divided into three compartments with a duct envelope entering and leaving each compartment. At tap points and at corners, this led to some very difficult problems in getting envelopes away from the manholes at 90 degree angles from three compartments. The method used for accomplishing this is shown in Figure 3. Pulling-in irons were provided opposite all duct entrances in manholes.

Manholes were spaced a maximum of five hundred feet apart with manholes located at intermediate distances to provide for future load areas. Use of intermediate manholes was resorted to when an abrupt change in elevation was required to clear an underground obstruction. In one case, it was necessary to tunnel underneath an existing mill from north to south at an elevation which required blasting away one of the main table foundations without shutting down the mill. At the south end of this tunnel, it was necessary to construct a manhole 25 feet deep in order to get under a sewer which was too near the surface to allow the envelopes to cross over the top.

Power cables consist of 15 kv, 3 conductor, 500 mcm, paper insulated, sectored type "H" cable, lead covered. At all terminals, 25-kv potheads were applied in order to provide increased flashover and creepage protection.

A spiralled copper ground element was buried in coke breeze underneath the floor pad of each manhole, and taps were brought through the floor of each manhole compartment. The sheath of each cable was bonded to this ground element. Cables were fireproofed in all manholes and at all switchgear entrances between the floor and the pothead.

In the case of the new bessemer plant, it was necessary to carry the lines overhead as open wire lines for part of the distance because a concentration of existing buildings made it impossible to excavate for an underground duct line. At the point where the transition from underground construction to overhead construction was made, a fenced in transition tower was provided. Arranged as shown in Figure 4, this tower and its fence enclosure incorporate the potheads at the cable ends, the line arresters, grounding switches, and bus bar risers between the potheads and the overhead lines.

Two similar towers were used previously in putting the main 25-cycle, 6600-v distribution lines underground to clear the site for the No. 4 seamless mill.

Pilot cables were carried on messenger wire from the transition tower to the receiving end of the line. For this line section, lightning arresters were provided at the junction of the overhead and underground line sections and at the receiving end of the open wire line. The overhead lines were carried on H-frames made up of swaged pipe poles laced together as shown in Figure 5. Line post type insulators rated at 25 kv were used.

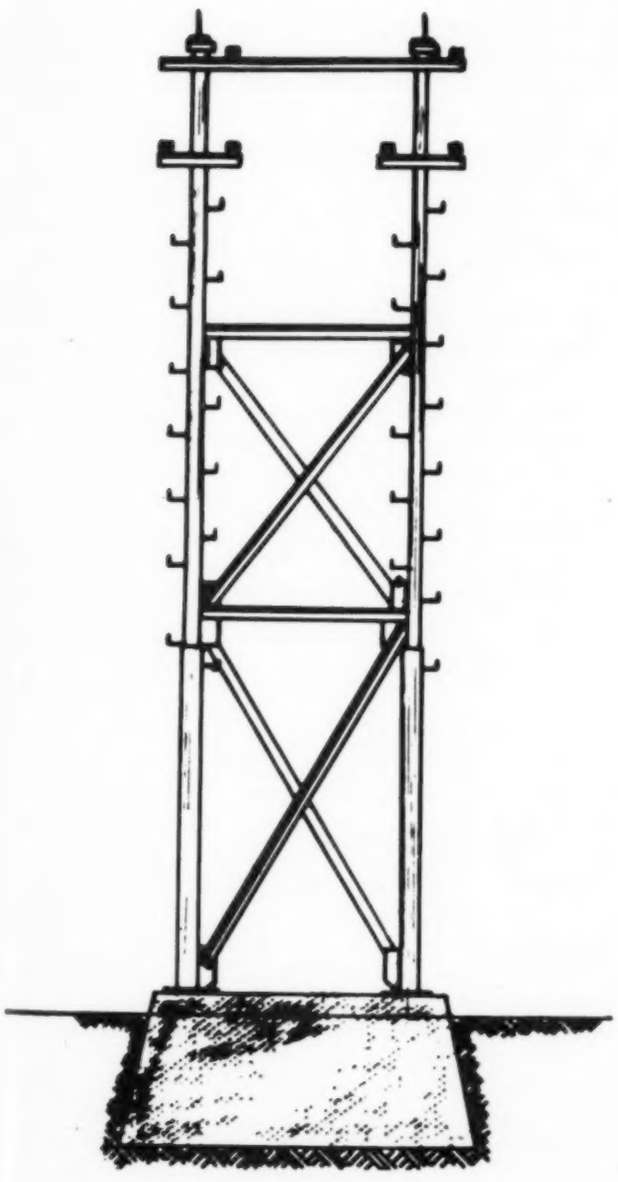
It is significant that despite the fact that every known

precaution was taken to make this aerial line trouble free, it is the only line of the new system which has failed during the months that the system has been in operation. These failures were due to dirt collection on the line posts and serve to emphasize that outage-proof, open wire lines cannot be built in a steel mill.

The mass of experience gained in operating open wire lines associated with the Lorain works, 25-cycle system further emphasizes the superiority of underground systems over aerial open wire lines for steel mill service. Line failures from crane booms swinging into open lines have contributed much to the poor service record of open lines of the 25-cycle system.

Of prime importance also, have been motor failures on the 25-cycle system due to end turns damaged by induced voltages during the lightning season. While this comparison does not begin to cover a long enough period of operation to bring out any hard and fast conclusions, it does point up a trend which substantiates the original thinking that dictated the choice of an underground cable system.

Figure 5 — Typical overhead structure.



While this discussion has been limited to underground and open wire lines, we cannot afford to lose sight of the fact that advances in cable manufacture have made available new techniques which offer great promise. Of particular interest for steel mill use are the high voltage type "H" cables with synthetic sheaths, instead of lead, protected by interlocking armor. These cables can be racked from point to point on existing building structures or on light structures erected specifically for their use. They give the protection from dirt and lightning inherent in cable, yet are accessible for the cutting out and replacing of faulted sections. At the same time, they offer substantial savings in labor by the elimination of conduits and potheads.

There is no question, however, that methods are now available to provide distribution lines for steel mills which are substantially trouble free, and that the cost of these methods can be more than offset by the savings in maintenance costs and production loss.

DISCUSSION

PRESENTED BY

F. V. CALVERT, Construction Materials Department, General Electric Co., Cleveland, Ohio.

A. A. JOHNSON, Manager, Central Station Engineering, Westinghouse Electric Corp., East Pittsburgh, Pa.

F. O. SCHNURE, Electrical Supt., Bethlehem Steel Co., Sparrows Point, Md.

J. E. BODOH, Electrical Engineer, United States Steel Co., Gary Steel Works, Gary, Ind.

F. H. WICKLINE, Construction Engineer — Electrical, National Tube Co., Lorain, Ohio.

P. R. PIERSON, Westinghouse Electric Corp., East Pittsburgh, Pa.

D. L. BEEMAN, Manager, Industrial Power Div., General Electric Co., Schenectady, N. Y.

F. V. Calvert: Mr. Wickline's paper brings out the need for the best possible equipment that can be purchased. In looking back over a long period of years, it seems that the steel industry has been somewhat conservative in taking advantage of the technique of power cable distribution.

In the Lorain area, and in northern Ohio, including the Mahoning Valley, there is much free lime in the soil, and experience has shown that all lead cables should have auxiliary protection over the lead to protect the lead against corrosion, and to offer additional mechanical protection.

Although such finishes have been available for the past few years, only recently has the cable industry gone all out to promote such additional protection. I know Mr. Wickline is well aware of it, and on future installation he will provide additional finish for the cable.

Probably the most successful of these finishes is the use of glass tape impregnated with neoprene, which gives good chemical protection, plus a non-rotting, highly adhesive finish, to withstand mechanical abuse during installation.

Mr. Wickline has designed a most rugged underground system, and the only point in the design I have questioned is the large number of ducts in each bank. The optimum number of leaded cables in a duct bank is usually nine. If the load factors are not severe, one can go to twelve loaded cables. The danger of having too many spare ducts comes in their use by individuals who may come after Mr. Wickline has been promoted.

The second item is the extensive use of the 2300-v system in the new mill. The trend is definitely toward 4160 and 13,800 volts for larger blocks of power. The mining industry in its search for higher safety factors has gone to 4160 v in preference to 2300 v. However, steel mill electrical engineers find that 2300-v circuits can be adequately grounded and works best for local utilization.

One thing that does stand out in the paper is the fact that the only weak point in the entire system is the open wiring, subject to lightning, and that more trouble has been experienced in that section than in any other part of the system.

Underground seems to be the best place in the world for a cable, but we have learned in the last few years that a very high degree of safety at lower cost can be obtained by using armored cable in air. Mr. Wickline has used such construction in several sections of his plant and in closing his paper he emphasized the fact that on future mills armored aerial cables installed on suitable racks (which were not available three or four years ago) will help designers in the steel industry to provide dependable cable lines at a cost way below that of an underground system.

Such construction will also permit prompt restoration of service in case of cable failures and make it easy to add cables with a minimum of work.

A. A. Johnson: In the early stages of planning this 13.8-kv distribution system, it was decided that it should be resistance grounded. In my opinion this was a major step and a proper one because a single-line-to-ground fault at any point on the 13.8-kv circuits or apparatus would be detected and the faulted equipment would be moved from the system. Many distribution systems, both in industrial plants and in power companies, have been operated ungrounded and many are still in operation. The argument in favor of the ungrounded system is that operation can be continued with one phase grounded as can be demonstrated from Figure 6. The system can operate with a line-to-ground fault on one phase such as phase A as long as there is no fault on either of the other phases. It should be pointed out, however, that a line-to-ground fault on one phase, is conducive to trouble on a second phase because the other two phases are at full line-to-line voltage above ground. If a second phase-to-ground fault appears on a different feeder circuit before the first fault has been removed, this is then a phase-to-phase-to-ground fault and two circuits will trip out. In addition to the normal line-to-line voltage to ground on two good phases, it is possible that excessive transient overvoltages may be produced, resulting in the failure of a second phase. This may come about by the initial line-to-ground fault having an arcing phenomena with the arc going out and restriking at such intervals as to produce transient overvoltages from two to perhaps five times normal line-to-ground peak values. These transient overvoltages may and probably have caused the failure of many motors which, if the system had been grounded, would not have failed. In selecting a resistance of 8 ohms for each transformer 13.8-kv neutral, the line-to-ground fault current is limited and the resistor limits transient overvoltages to safe values.

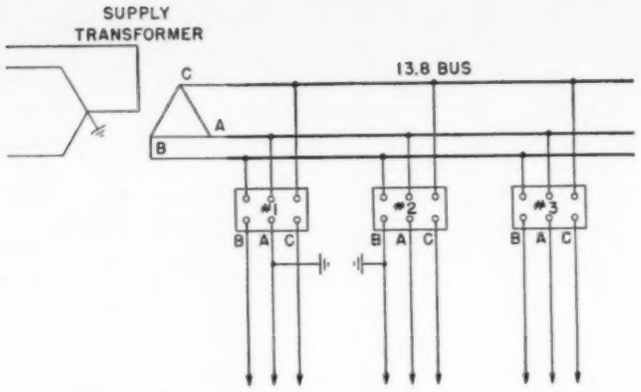
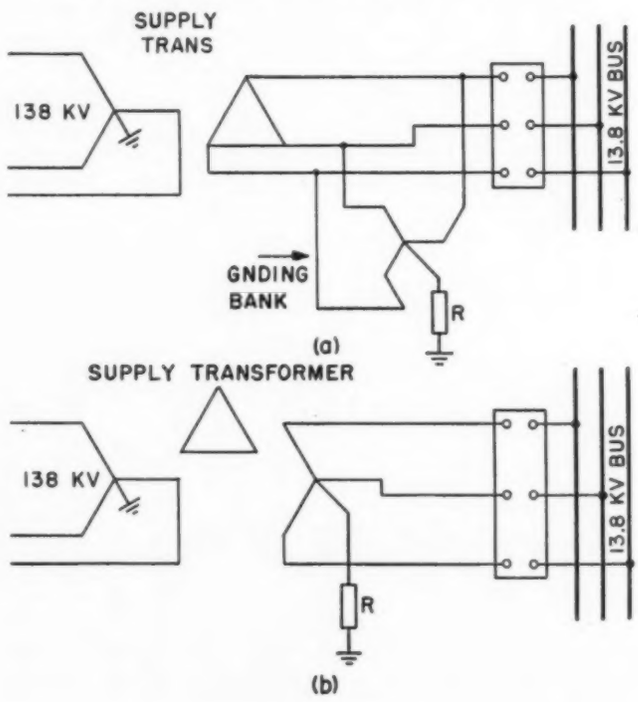


Figure 6 — An underground system may be continued in operation with one phase grounded.

To provide a neutral point for the neutral resistors, the first plan for the 13.8-kv distribution system was to provide a zig-zag grounding transformer on the secondary of each 15,000-kva supply transformer as shown in Figure 7a. This was necessary since the original idea was that the supply transformers would be wye connected on the 138-kv side, and delta connected on the 13.8-kv side. This transformer was considered because it was the most economical type to purchase. Using a zig-zag grounding transformer was complicated and costly because all of the bus work was to be metal enclosed. It was at this point in the planning that I suggested the use of the three-winding transformer shown in Figure 7b having wye connection on the 138 kv, wye connection on the 13.8 kv, and a delta tertiary to

Figure 7 — Sketch shows schematic of resistor grounding. The scheme on the bottom was the one adopted.



suppress harmonic voltages. In this way each main transformer bank provided a neutral point for connecting a grounding resistor. This scheme was adopted because it was much simpler and was also less costly. Likewise it eliminated an extra piece of equipment which took space as well as maintenance.

In this distribution system, Mr. Wickline has stressed safety. I believe that when he used the word "safety" in his paper, he was referring primarily to safety to employes. However, he has demonstrated by the use of metal-enclosed bus structures and cable circuits, the grounding scheme, types of relays, and interlocking devices that he has also taken care of the safety to its electrical equipment. Interlocking devices particularly prevent human errors. In the operation of distribution systems human errors cause as much serious trouble as do the elements.

Mr. Wickline has stressed reliability and has provided a type of system to get reliability. The use of underground cables in ducts is an accepted way to get the best possible service. I would like to suggest, however, that for certain feeder circuits, where the soil conditions will allow, that the cable might be buried directly in the ground. If trouble should develop, the fault can be located within a few feet by suitable terminal measurements and the cable dug up in the right spot and repaired. Buried cable might have the same type of construction as do submarine cables on which there are records of many, many years of successful operation at voltages of 13.8 kv and higher. I also understand that lead-covered cables are buried directly in the ground in a few places in this country with satisfactory performance. Buried cable is common practice in some other countries of the world. It is my prediction that more use will be made of buried cable in this country both for industrial systems and utility systems.

It was pointed out in the paper that 13.8 kv gave a well balanced system both with respect to switchgear and a-c drives. It was also stated that 13.8 kv brings the system well into the range of reliable cable operation. While for this system it is obvious that a voltage above 13.8 kv would not be practical because of equipment considerations, it should be added that very reliable operation of cables above 13.8 kv on up through 138 kv has been conclusively proven. There are many thousands of miles of 23 kv and 27 kv in service.

Such papers as the one presented by Mr. Wickline are welcomed by the manufacturers of electrical equipment because they give practical guidance to both the design and the application engineer.

F. O. Schnure: The selection of a transmission system to serve a steel plant depends largely upon the local characteristics. In this paper the author has selected underground transmission for a number of reasons: load, voltage, safety, the comparatively short runs and low capacity involved.

Our experience with underground does not entitle me to be an exponent for or against it, but I recall very distantly the remarks of a gentleman who for many years was in charge of both overhead and underground distribution of our local utility. We were discussing the flooding of conduits to increase the capacity of the cables. It was, "stay overhead until forced underground." And indeed, that has been our policy. Of course our location 15 feet above sea level predicts flooded manholes; a widely spread out plant indicates a costly system, and a growing plant means that many location changes may be required. A mill now under construction required a great many changes to the existing transmission and distribution system.

Because of the difficulty in draining conduits and manholes in our area, aerial cable supported on messengers has been widely used in the 6.9 kv distribution range. This type of transmission is not subject to lightning troubles, is very seldom struck by cranes and has possibilities of excellent life. A 3-conductor 300,000 cm overhead cable with varnished cambric insulation suitable for 15 kv service has been operating from our power house to a pumping station for 27 years. It is still in service even though the armored tape has disappeared in spots and the jute and marlin covering require a "haircut" from time to time.

A plan for a distribution system should bring the transmission voltage, whether it be 132, 66, 33 or "what have you," as close to the load centers as possible. From that point on, the imagination should go into high gear. If underground is indicated, well and good, but do not neglect the possibilities of overhead aerial cables and the overhead lines if protected from lightning. It has most excellent load carrying capacity, and is comparatively easily and quickly repaired.

J. E. Bodoh: I fail to agree with Mr. Schnure, where he states that he prefers 6900-v and 2300-v overhead distribution in steel plants. Our distribution circuits on above voltages are all underground, and we have experienced exceptionally good results; therefore, we intend to continue this practice.

I would like to ask Mr. Wickline what consideration was given to the grounding of their underground cable system in regard to the new theories of corrosion prevention? I would also like to ask him what consideration was given to the problem of corrosion under the fireproofing on cables? We have found both of these problems to be very important in our plant and in neighboring plants in our district.

F. H. Wickline: In answer to Mr. Calvert's question about the large number of ducts per envelope, if you will remember, it was pointed out that ducts were included for future east and west expansion, including a possible 60-cycle power generating station.

The ducts which were provided in the beginning, give space for these future cables, without taking out of service the present cable. When the time comes to cut over from the utility to our own power house, which of course is tentative, it will not be possible to take the cable from service and have the plant out of production while we pull them out and put in new cables, where different routing is required. Without loss of too much time, existing cables may be cut out, and the power plant circuits may be cut in. In the final picture there will never be more than twelve energized cables in any envelope.

An interesting point brought up by Mr. Johnson was the protection of equipment, in addition to personnel protection. To show how thoroughly that has been provided, only a short time ago, a motor room attendant shoved a grounding device in on one of the incoming lines with the line hot, and closed the grounding breaker, putting a dead three phase short on one of the main incoming lines.

All the breakers on the bus tripped by bus differential relaying without even so much as burning a contact, and the mill was back in operation in a short time.

That, I believe, is illustrative of what Mr. Johnson meant by his reference to protection of equipment.

In answer to Mr. Bodoh's question, I would like to state that no elaborate measures were resorted to, to prevent sheath corrosion, other than to make sure that the copper grounding leads which were attached to each cable sheath in each manhole, were thoroughly imbedded in the lead to prevent the forming of local couples with their resultant electrolytic decomposition. No treatment of any kind was given the cable sheath underneath the fireproofing.

D. R. Pierson: Reference to the switchgear for the control of the distribution system, is limited, probably because it would have undesirably lengthened and complicated the paper. If we had access to the work books and data from which the choice of outdoor metalclad switchgear was made, we would undoubtedly find much interesting information comparing indoor and outdoor reliability, maintenance features and installed costs. It is a privilege to offer some additional thoughts for consideration in planning similar systems.

Lorain works of the National Tube Co. has partially in operation one of the largest installations now in existence of outdoor metalclad switchgear controlling 13.8-kv distribution. At present about 40,000 kva is distributed and controlled by this installation. This will be eventually increased to 60,000 kva. It is a distinct credit to the past performance of outdoor metalclad switchgear to have it selected for this installation where continuity of service and reliability of the electrical system are of prime importance.

Metalclad switchgear is an obvious choice for a distribution system of this type. The system planning requires a choice between an indoor or outdoor installation. Several factors must be considered in making the selection. First, is relative reliability, second, relative cost, third, facilities and requirements of maintenance and fourth, effects of outdoor location on service continuity.

Outdoor metalclad switchgear has a background of years of reliable service on 13.8 kv systems. Installations existing in all parts of the United States have built up a reputation for reliable operation equaled only by indoor installations of similar equipment. The close permissible association of outdoor metalclad switchgear and large associated power supply transformers practically eliminates the hazard of faults in the important power connection between the two.

Present day cost of building construction favor outdoor metalclad switchgear from an installed cost view point. The concrete slabs which support the switchgear are relatively easy to design and inexpensive to build. The switchgear being factory built and self contained can be installed with a minimum of labor and time.

Outdoor metalclad switchgear may require somewhat more maintenance than indoor installations depending on dirt content of the local atmosphere available for ventilation. Under reasonable weather conditions, maintenance operations on outdoor or indoor installations are equivalent. By an aggressive program of preventive maintenance during reasonable weather periods, work during bad weather can be reduced to a minimum.

A well planned installation can reduce the effects of maintenance requirements to a minimum. At Lorain, the multiple bus arrangement permits a complete bus shut down for overall inspection of the transformer, tap changer and switchgear bus. The multiple feeds to use locations permits a feeder shut down without complete service interruption. As a result, a delay in servicing a circuit because of bad weather is not serious. The same system would have undoubtedly been used with indoor equipment therefore incurring no extra equipment costs.

For installations of this type, outdoor metalclad switchgear with drawout breakers is ideally adapted. Inspection of breakers can be easily and quickly performed by removing the barrier assembly without the need of accessory equipment. The breakers can be moved to a central location for major maintenance operations where their self contained wheels simplifies movement. A spare breaker can be used to maintain circuit operation.

Briefly summarizing, the use of outdoor metalclad switchgear can contribute to reliability of service by reducing the length of supply circuits. Installed costs are materially reduced by the elimination of building design and construction. Well planned maintenance can keep unavoidable interruptions to a minimum. A well planned distribution system can minimize the effects of unforseen service requirements.

D. L. Beeman: The author brought out very effectively that there are two very important things you have to do when you design a system. One is to make the system one-line diagram. The other is to select the right kind of equipment. So far as the system is concerned, the author and others have mentioned the question of voltage, ground, circuit arrangements, etc. I would like to comment regarding the 4160 and 13.8 kv selection. The studies which we have made and which I think have been substantiated fairly widely through the industry indicate that where 13.8 kv is the generation and transmission voltage, 13.8 kv can be used very effectively directly on motors about 2000 hp and above. Four hundred eighty volts can be used effectively on motors 200 or 300 hp and less. In the area in between these horsepower ranges an intermediate voltage is more economical. For that area in such mills as the one at Lorain, 2300 v generally works out much better than 4160 because 2300 v is not a distribution voltage but a utilization voltage and is generally confined to a spot area.

On the other hand, a small plant where the load is up to about 10,000 kva, 4160 v would work out better as a plant distribution voltage than 2300 v.

Twenty-three-hundred-volt systems can be grounded just as effectively as 4160-v systems. Either 2300-v wye connected transformers or grounding transformers can be used to obtain the neutral for grounding.

With reference to the question of dirt and cleaning of insulators, there is available now the equipment to do a completely metal-enclosed job in systems 15 kv and less. Circuit breakers, substations and buses can be enclosed in grounded metal and cables may also have metal enclosure. The enclosure does two things. It keeps the dust and dirt out and provides for safe operating conditions in the grounded metal between the personnel in the plant and the live electrical conductors.

Economics of Purchased Power VS Plant Generated Power in the Pittsburgh District

. . . . paper presented before Engineers' Society of Western Pennsylvania-Steel Works Section, April 24, 1951 . . . . study is based on new January 11, 1951 power rates . . . .

By W. B. SKINKLE
Consulting Engineer
Pittsburgh, Pa.

▲ THIS study was prepared for the purpose of comparing the economies of purchasing electrical energy with those derived from generating power in a plant-operated station.

The board of directors of any business concern is primarily interested in making a profit. In order to do this, management must be well acquainted with all expense items so that it can control these items most efficiently and, consequently, produce a maximum profit.

With the rapid improvement and the modern design of electrical equipment, every major industry has become a large consumer of electric power. The result is that electricity now constitutes an appreciable portion of the total expense incurred by most business concerns. There is no doubt that the directors of these same concerns have often considered the possibility of producing, in their own plant, the required amount of electrical energy at a cheaper rate than they could purchase it from the utility company. Such an undertaking requires an extensive study, too lengthy and involved in its complete form for presentation to a busy executive. It would seem helpful, therefore, to present a condensed version of such a study.

In this paper, the author has explained the essential features contained in the Duquesne Light Co.'s Rate Schedule "W," effective January 11, 1951, and compared the cost of purchasing power under this rate with the cost of constructing and maintaining an isolated, coal-fired generating plant of the same capacity.

Each public utility rate is drawn up by the company to meet the needs of a certain class of customers whose business or operations enable them to meet the conditions which limit the application of the rate.

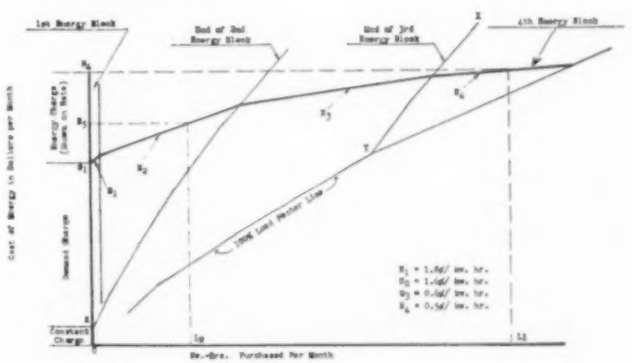
Rate "W" is the General Service Schedule which is available to all classes of service where the customer's connected load is equal to or greater than 5 kva and less than 18,000 kva.

GENERAL

When large blocks of power, such as are covered by this rate, are sold, the cost to the customer must be low in order that the utility can compete with the cost shown by a customer-owned power generating station.

When a utility sells power at a price so low that it closely approaches the cost of production, the margin of profit is so small that small changes in either producing conditions or consuming conditions could easily turn this small profit into an actual loss. The conditions of sale of energy under rate schedules of this kind must therefore be thoroughly protected by rigid clauses which will cover changes in the cost of production, and

Figure 1 — Cost of energy can be divided into three parts, a constant charge, an apparent demand charge, and an energy charge.



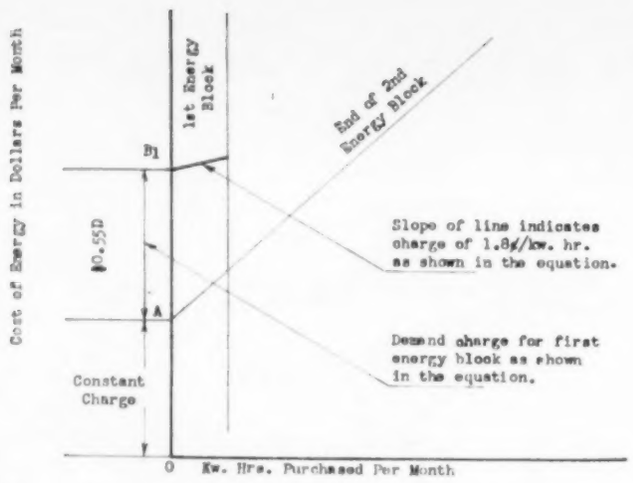

Cost of Energy in Dollars Per Month
1st Energy Block
End of 2nd Energy Block
B1
$0.55D
A
Slope of line indicates charge of 1.8¢/kw. hr. as shown in the equation.
Demand charge for first energy block as shown in the equation.
Constant Charge
0
Kw. Hrs. Purchased Per Month

Figure 2 — Chart shows cost of energy purchased in the first energy block.

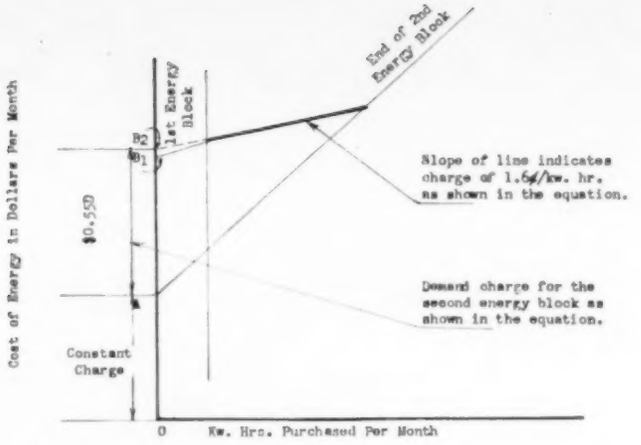

Cost of Energy in Dollars Per Month
1st Energy Block
End of 2nd Energy Block
B2
B1
$0.55D
Slope of line indicates charge of 1.6¢/kw. hr. as shown in the equation.
Demand charge for the second energy block as shown in the equation.
Constant Charge
0
Kw. Hrs. Purchased Per Month

Figure 3 — Chart shows cost of energy purchased in the second energy block.

also impose proper penalties on a customer that is either careless or abusive in his method of operation.

The only control a utility can exert over the use of power by a customer, is through its rate schedule; consequently, if the customer is careless or abusive in his method of use, and in this way unduly increases the utility's cost of rendering the service, the utility must, in self-defense, arrange its rate schedule so that the increase in cost will be reflected back onto that customer's power bill.

On the other hand if the customer is careful, and both the utility and the customer work in close cooperation with each other, there is an opportunity for both interests to profit through the association of buyer and seller.

Public utility rate schedules can all be analyzed and put in the form of algebraic equations, which equations will show that the total bill for electric energy is made up of three parts, viz., a billing demand charge; a charge for the energy used; and a constant charge of a definite amount of money. These three charges when added together make up the total bill.

As an example of this, the equation for energy purchased at demands between 100 kva and 300 kva and load factor greater than 12½ per cent shows that the total net monthly bill is made up of $1.90 times the demand in kva, plus $0.006 times the kwhr consumed, plus a constant charge of $103.50. The scientific purchase of electric energy depends entirely on the study and control of these items or on the control of operating conditions which may effect them.

ESSENTIALS OF THE RATE

The following features appearing in the rate schedule are considered of major importance in the economic purchase of electric energy:

1. Net monthly bill.
2. Determination of the "billing demand."
3. Power factor correction.
4. Minimum monthly bill.
5. The price of coal (applicable to all energy above the first 1,000 kilowatt hours purchased in any month.

These items will be discussed in detail.

MONTHLY BILL

The real or mathematical method of determining the *net monthly bill* was seen in the foregoing paragraph marked "General" to be $1.90D + 0.006E + 103.50$

D = the "billing demand" in kva.

E = energy consumed in kwhr per month.

This equation is made up of two variables, viz., a "billing demand" charge, and "energy" charge plus a "constant" charge, amounting to $103.50 per month. This equation only holds true for demands between 100 kva and 300 kva and energy consumed equal to more than 1000 kwhr plus 80 hour use of the "billing demand" and for service below 4000 volts.

The problem facing the purchaser is to so regulate and control his operating conditions that the *sum* of these three charges will result in the lowest possible bill for the electric service that will permit him to properly conduct his business on an efficient and satisfactory basis.

By changing the rate schedule into the form of an algebraic equation, it is at once apparent that the lowest bill can be obtained through control of the only two variables, viz., the "billing demand" and the "energy." Nothing can be done to change the "constant" charge at the end of the equation. The consumption of energy (kwhr) is usually associated with, and very closely related to, production, or the volume of business. Furthermore, the cost of the energy is small, (being only 0.6¢ per kwhr). A reduction in kwhr which was obtained through reduced production and in reduced revenue would be an unprofitable and uneconomical method of reducing costs.

The "demand charge," being the only factor left, is the item which offers the greatest opportunity for reduction in power costs. Any factor which affects the demand and which will tend to reduce the demand will have a considerable influence on the power bill.

DEMAND

Usually there are two kinds of demand associated

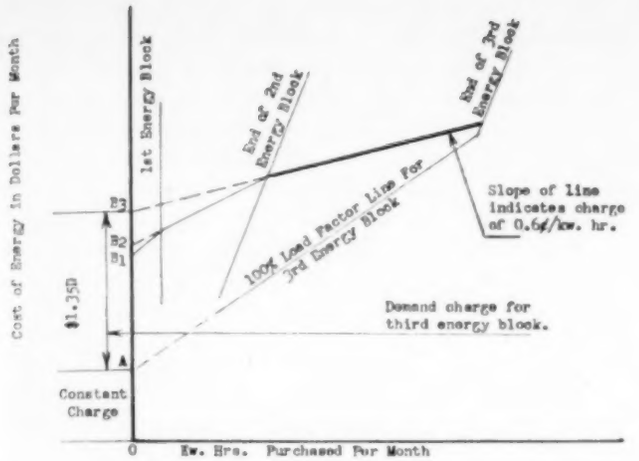


Figure 4 — Chart shows cost of energy purchased in the third energy block.

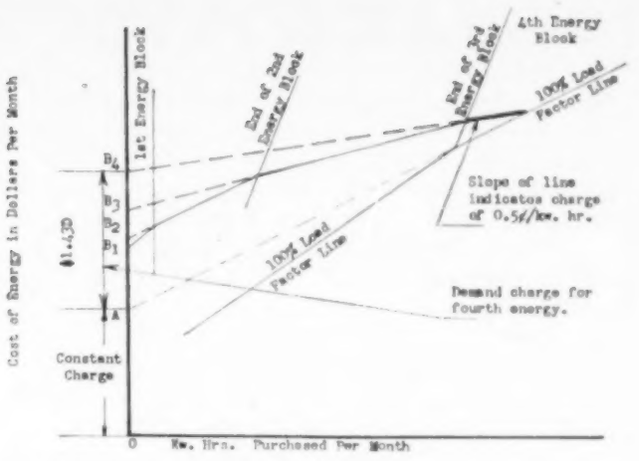


Figure 5 — Chart shows cost of energy purchased in the fourth energy block.

with the purchase of electric energy, they being the "measured demand" and the "billing demand." These two demands are the same only when the power factor is unity (100 per cent), or "leading." If the power factor is lagging (which usually is the case unless special precautions are taken to avoid the lag) the "billing demand" is larger than the "measured demand." The full effect of this lagging power factor will be explained later under a paragraph titled "Power Factor."

As commonly presented by the utility schedule, the real demand charge is not apparent until the schedule has been subjected to mathematical analysis.

Some utility schedules apparently do not have a so-called "demand" charge inasmuch as no such charge is directly made in the schedule. A mathematical analysis of the schedule will reveal, however, that there is a considerable demand charge. For a given measured demand, these demand charges become larger with increased use of energy.

This can be illustrated graphically as shown in Figures 1, 2, 3, 4, and 5. In all of these figures the "Cost of Electric Energy in Dollars Per Month" is used as the vertical ordinate, and the "Kilowatt Hours Purchased Per Month" is used as the horizontal ordinate. The money values used will be taken from Rate "W" for demands between 300 and 1000 kva.

Energy is sold in this schedule in four "energy blocks" and at the following rates:

First block—1.8¢ per kwhr net
Second block—1.6¢ per kwhr net
Third block—0.6¢ per kwhr net
Fourth block—0.5¢ per kwhr net

Referring to Figure 1, the heavy line in the figure represents the manner in which the cost of electric energy increased with use for a given demand. In this figure, the energy used during the month is equivalent to the horizontal distance "OL_1" and the total cost of the service is equal to the vertical height "OB_4." The cost of this energy can be divided into three parts, viz. (1) a "constant" charge equal to the vertical height "OA" (this is the value shown at the end of the equation), (2) an "apparent" demand charge equal to the vertical height "AB_1," and (3) an energy charge equal to the vertical height "B_1," "B_4."

The light line representing 1000 kwhr, the first energy block the light line from point "A" showing the limit of the second energy block, and the light line "XY" shows the limit of the third "energy block" which are sold at rates decreasing from 1.8¢ per kwhr in the first block to 0.5¢ per kwhr in the fourth or "excess" block.

If the energy used has been reduced to an amount equal to the horizontal distance "OL_2," the cost of the service for the same demand would have been equal to a cost represented by the vertical height "OB_5." It can be seen that for a given demand a relatively large reduction in the amount of energy used (kwhr per month) makes only a comparatively small reduction in the cost of the service. (This reduction in cost is represented by the vertical distance between points "B_4" and "B_5.")

By constructing a "family" of curves each representing the manner in which the cost of electric energy increases for a different demand, a graphic representation of the whole rate structure can be illustrated. Such a "family" of curves may be seen Figures 11, 12, 13, 14 at the end of this study.

It will be noticed that in the foregoing paragraphs, mention was made of the "apparent" demand charges as set forth in the rate schedule. The word apparent was used because the demand charge specified in the rate schedule applies only to the first and second energy blocks. The third and fourth energy blocks have different "real" or mathematical demand charges.

The real or mathematical demand charge could be defined as the quantity of money by which the electric bill changes for each kilowatt (or kilovolt ampere, kva) change in the billing demand.

Referring to Figure 2 which shows by the heavy line, the change in the power bill when energy is purchased in the first energy block, it will be seen that the total cost of energy will be made up of the usual three items, viz., (1) a constant charge equal to the vertical height "OA," (2) a demand charge equal to the vertical height "AB_1," and (3) an energy charge which will increase the bill along the slope of the heavy line until it reaches the limit, or end, of the first energy block.

After reaching the limit of the first energy block as indicated in Figure 2, an increase in energy consump-

tion will cause an increase in the electric bill as indicated by the heavy line in Figure 3 up to the limit or end of the second energy block. Notice, however, that within the limits of the second energy block, the total cost of electric energy is still made of the sum of three items as before, namely: a constant charge equal to the vertical height "OA" (which may or may not be the same as that shown in Figure 2), plus a demand charge equal to the vertical height "AB_2" (which is equal to the demand charge used in Figure 2 for the first energy block) plus an energy charge which increases along the slope of the heavy line in the figure. The slope of this line, which represents the rate charged per kwhr is less for the second block than it is for the first energy block.

In like manner Figures 4 and 5 show the cost of electric energy when purchased in the third and fourth energy blocks. Note in both Figures 4 and 5 that the demand charges for preceding blocks are indicated by the vertical heights from A to B_1, B_2, B_3, etc.

Figure 5 illustrates the increasing "real" or mathematical demand charge for the last energy block. The third energy block begins at approximately 12 per cent load factor*, which represents only 12 per cent of the possible 24 hours use of a given demand, and the fourth block is 300,000 kwhr more than the third. Load factor, necessary to reach the fourth block, should not be difficult for nearly every customer to reach. The equations for the third and last energy blocks are therefore the most important ones to consider when studying the economical purchase of electric energy under this rate schedule "W."

The effect of load factor on the cost per kwhr is shown in Figure 6.

POWER FACTOR

The explanation of what power factor is requires an involved and technical discussion which is beyond the understanding of the average purchaser of electric energy and will be avoided in this study.

The explanation of what bad power factor does to the generating equipment of a utility company is comparatively simple and will therefore be used in place of the more technical discussion.

The power factor at any purchaser's switchboard is determined entirely by the character of, and the load on, the consumer's electric equipment. The power factor at any purchaser's switchboard is entirely within his own control and is beyond the control of the utility furnishing the power.

The power factor on the utility company's generating equipment is determined by the general or "weighted" average of the power factors of all the consumers.

If the utility company should, for example, have a 10,000 kw generator in operation; and if the consumers had electric equipment of such a character that the power factor was only 50 per cent, the 10,000-kw generator would only produce 5000 kw of power. If on the other hand, the consumers electric equipment was of such a character that 100 per cent (unity) power factor was maintained, the 10,000-kw generator would then produce 10,000 kw. This would enable the utility company to sell just twice the product from a given installation as it could sell under the first set of conditions mentioned; namely 50 per cent power factor.

In like manner the capacities of transmission lines and transformer stations are all affected by bad power factor.

For this reason the utility company does either one or two things, viz., (a) it sets a higher rate and then offers a premium on power factors that approach 100 per cent (unity) in the form of attractive discounts, thereby reducing the monthly bill to consumers who maintain high power factors, or (b) it places a heavy penalty on bad power factors that vary from 100 per cent (unity), thereby increasing the power bill of the careless purchaser and causing him to pay the utility company at least a large part of the profit that might have been made had the power company been able to sell the output of the generating and transmitting capacity which the consumer's bad power factor rendered unavailable for use.

Rate "W" is of the latter form and imposes a penalty on the bad factor customer.

The power factor may be either lagging, unity (which is 100 per cent), or leading.

From a purely electrical standpoint, a leading power factor is as bad as a lagging power factor, except for the fact that probably more than 90 per cent of the customers have a lagging power factor and very few customers have a leading power factor. A few leading power factor customers materially help to balance the large number of lagging customers and for this reason the utility companies do not place penalties on the leading power factor customers.

CAUSES OF BAD POWER FACTOR

Electric motors using alternating current are of two general types, viz., induction and synchronous. Induction motors usually cost less than synchronous motors of similar capacity. Most customers who purchase motors want "plenty of motor" for as little money as possible, and many machines are thus badly over-motored with induction motors. The customer fails to realize that an induction motor which is underloaded gives a very bad lagging power factor. Installations where the induction motor is so oversized and underloaded that its resulting power factor is from 20 to 40 per cent are not at all infrequent. Such motors make large additions to the power bill of any customer.

On the other hand, the more expensive synchronous motors which are underloaded, tend to give a leading power factor. Purchasers of electric energy are nearly always confronted with the problem of balancing their induction and synchronous equipment in such a manner that unity power factor or a slight lead in power factor will result. It frequently happens that a synchronous motor can be purchased and operated at no

* Load factor is the ratio of the amount of power used at a given demand, to the amount of power it is possible to use at the same demand in a given time. Example: 500,000 kwhr used at 1000 kva demand. Maximum possible use is 1,000 x 730 = 730,000 kwhr. Load factor $= \frac{500{,}000}{730{,}000} = 68.4$ per cent.

load except for its own friction and windage losses, and the resulting strong leading power factor is used to correct a bad lag on other induction motors that are already installed. A synchronous motor operated in this manner is called a synchronous condenser. Each type of motor has definite limitations in the field of application and in many cases the load conditions make one or the other type of motor necessary. The two types are not, therefore, interchangeable on every application.

Ordinary light bulbs of the mazda type give unity (100 per cent) power factor.

There are also several types of special motors, some of which are quite expensive, that may be used on special applications for the correction of power factor.

Bad power factor also has another source of loss for the consumer in that some of the electric energy for which the customer pays is converted into heat and lost in this manner by what is known as the wattless current.

KVA COMPARED TO KW

The manner in which the utility company adds the penalty for bad power factor to the customer's power bill is by putting the rate schedule on a kva (kilovolt ampere) basis instead of a kw (kilowatt) basis.

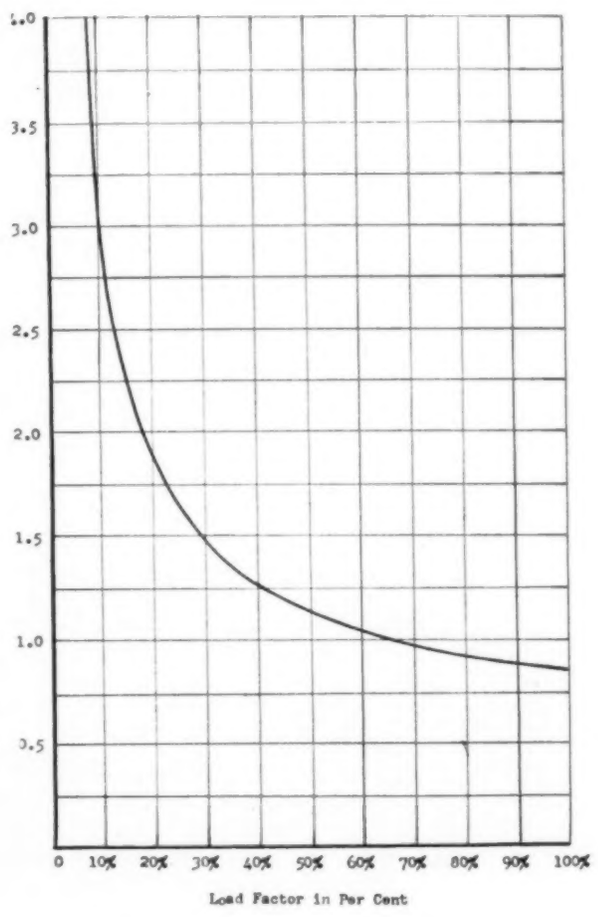
A kilowatt (kw) is a definite unit of work or heat, and it represents a definite rate of supply of energy which if continued for a definite time will give a definite number of kilowatt hours (kwhr) of energy.

The unit kilovolt ampere (kva) is obtained by dividing the kilowatts by the power factor, and inasmuch as the power factor can never be greater than unity (100 per cent) or the unit one, it will be seen that if the power factor varies from unity, the kva, will always be larger than the kw.

As an example, 120 kw at unity power factor gives $\frac{120}{1.00} = 120$ kva, but 120 kw, at 75 per cent power factor gives $\frac{120}{0.75} = 160$ kva.

Under the paragraph titled "Demand" it was stated that there were two kinds of demand, viz., the measured demand and the billing demand. In the cases just cited, 120 kw measured demand at unity power factor would give 120 kva billing demand, and no penalty would be added, but in the second case 120 kw measured demand at 75 per cent power factor would give a billing demand of 160 kva. The customer would, therefore, be paying a penalty of 40 kva of excess demand which is added because of bad power factor. At this particular load, the rate schedule charges $1.90 per kva of billing demand so that the 40 kva of excess demand would add 40 x 1.90 = $76.00 to the power bill for that month.

Figure 6 — Increase in the load factor decreases the energy cost very appreciably.



DETERMINATION OF THE DEMAND

The measured demand for loads of 50 kva or greater is determined by meter and consists of the maximum fifteen minute use of energy at any time during the monthly period as set by the meter reading dates.

The utility company installs on the switchboard of the customer a demand meter, which records (in a great number of parallel vertical arcs, drawn by the recording pen of the instrument) the use of energy in each and every demand period of the month. Reproductions of small sections of such charts are shown in Figures 7 and 8. At the end of each demand period, a clock mechanism trips the pen and it returns to zero and starts drawing the demand curve for the succeeding period.

The length of these lines when multiplied by the proper meter constant shows that during a particular demand period under measurement, electric energy was used at the rate of a certain number of kw or, in other words, if the rate indicated by the length of arc had been maintained for one hour, the quantity of energy used would have been a certain number of kilowatt hours per hour (which is equivalent to kilowatts).

The highest single peak for any demand period as shown by the length of the longest arc is used in various ways by different companies to determine the demand on which the monthly bill is based. Inasmuch as a large percentage of the total bill is determined in this manner, the creation of single, or occasional, high peaks may be a costly matter for the customer.

The demand determined in this manner is what is generally called the measured demand.

Notice in Figure 7 (which is a section of a typical chart showing the maximum demand for the month)

that the highest peak is near the right end of the chart, and that the chart reading is 0.745. The "constant" of this particular meter is 100, so that the maximum kw demand for the month was 100 x 0.745 = 74.5 kw. The resulting power bill was high owing to the occasional high peaks at each edge of the chart section. Contrast the irregular workings shown in Figure 7 with the chart shown in Figure 8. This chart was picked because it represented the other extreme of regularity in the purchase of electric energy. There is, of course, an unavoidable change in load between the night and day conditions, but the dominant condition which exists is carefully maintained in as uniform a manner as possible. The working conditions which existed during the periods when these charts were made were so radically different that it would be almost impossible to produce a chart similar to Figure 8 under the working conditions that pertained when Figure 7 was made. The two charts are offered for inspection to first show the method and type of chart which determines the measured demand, and second to illustrate two extremes in operating conditions that may be encountered.

As an example, a purchaser may use approximately 100 kw for eight hours of every working day and nothing, or nearly so, at night and on Saturday afternoon and Sundays. Through some combination of circumstances, a larger power using machine may be placed in operation at some period when a number of other machines are already using the full average of 100 kw.

If this large machine used 50 kw and was kept in operation for only one fifteen-minute period, there would be created one single fifteeen-minute peak of 150 kw. This single peak would set the demand for the entire month. The creation of this one single peak would require the customer to pay for power on the basis of 150 kw instead of the average load of 100 kw. By using that one additional 50 kw of power for only one fifteen-minute period, the customer added 50 kw to the demand charge, which at $1.90 per kva added 50 x 1.90 = $95.00 to the power bill for the month. Continuing this same example, the 15 minute (¼ hr) use of 50 kw consumed only $\frac{50}{4} = 12\frac{1}{2}$ kwhr. These 12½ kwhr would, therefore, have cost approximately $\frac{95}{12.5} = \$7.60$ for each kwhr consumed. This is somewhat expensive power for almost any machine.

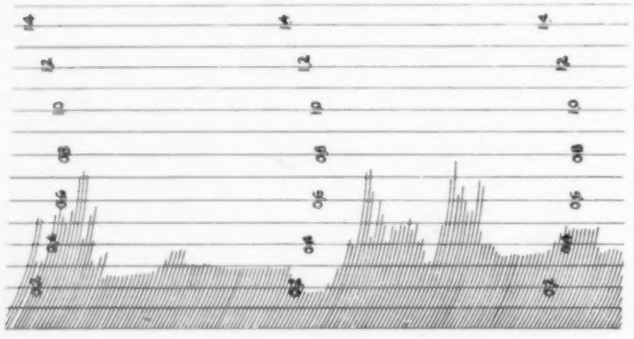
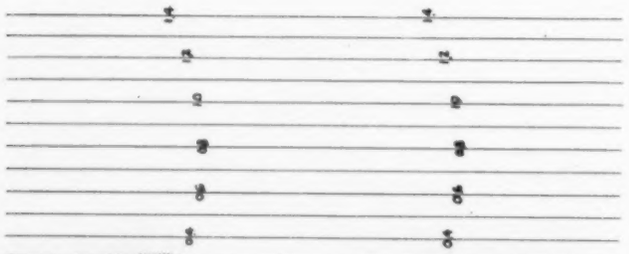


Figure 7 — The demand chart shows high peaks. The maximum in this case is 74.5 kw. These will result in a high power bill.

Figure 8 — By smoothing out high demand peaks as indicated on this chart, power costs are reduced markedly.



The example used is, of course, an extreme case, but instances where consumers have added more than one dollar per kilowatt hour to their bills for some short-period peak-power are not uncommon.

In rate "W", the demand charge throughout most of the possible operating conditions will constitute 22½ per cent or more of the total bill. The accompanying curve of Figure 9 illustrates this point. This curve is plotted with the per cent of the total net charges for power represented by the demand charge as the vertical ordinate, and the per cent load factor as the horizontal ordinate. Large demands for short periods of time give low load factors. A glance at the curve will show that at, for example, 40 per cent load factor, the demand charge represents 37 per cent of the total power bill, and at 60 per cent load factor the demand charge represents 28 per cent of the total power bill.

When service is taken at one or more than one point in a plant, the billing demand shall be the sum of the individual demands of each metered service supplied; provided, however, that the billing demand shall not be less than 50 per cent of the highest billing demand established during the six-month period previous to the billing date.

The individual demands of each metered service shall be determined separately. The individual demand shall be determined by measurement where the estimated demand is in excess of five kilovolt-amperes. Measured demands shall be determined in accordance with the company's standard practice and, except in unusual cases, shall be based on the maximum fifteen minute kilowatt demand.

There is only one way of avoiding high purchase power cost during periods of low operations, and that is by rigidly controlling the maximum 15 minute peak demands during periods of high operations.

MINIMUM MONTHLY BILL

The terms of rate "W" specify that the minimum monthly charge shall be $1.00 per kilovolt ampere for the greatest demand previously billed during the life of the contract. The demand charge referred to is the demand charge specified in the rate and may not be the same as the real or mathematical demand charge referred to previously in this study.

Using the example already cited of an abnormal increase for only one fifteen minute period of 50 kw on top of a 100 kw regular load, it will be seen that this

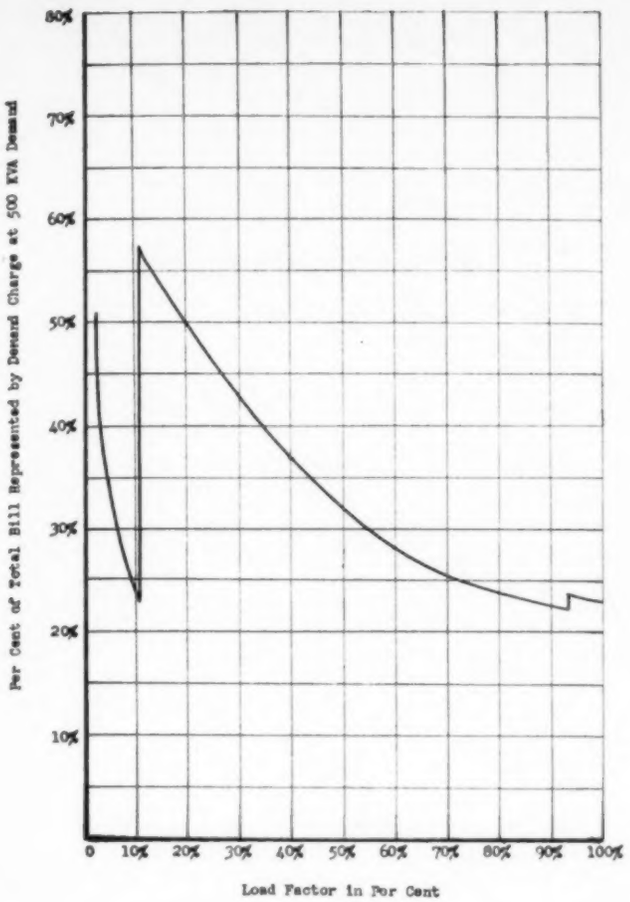


Figure 9 — The demand charge represents an appreciable percentage of the total power bill.

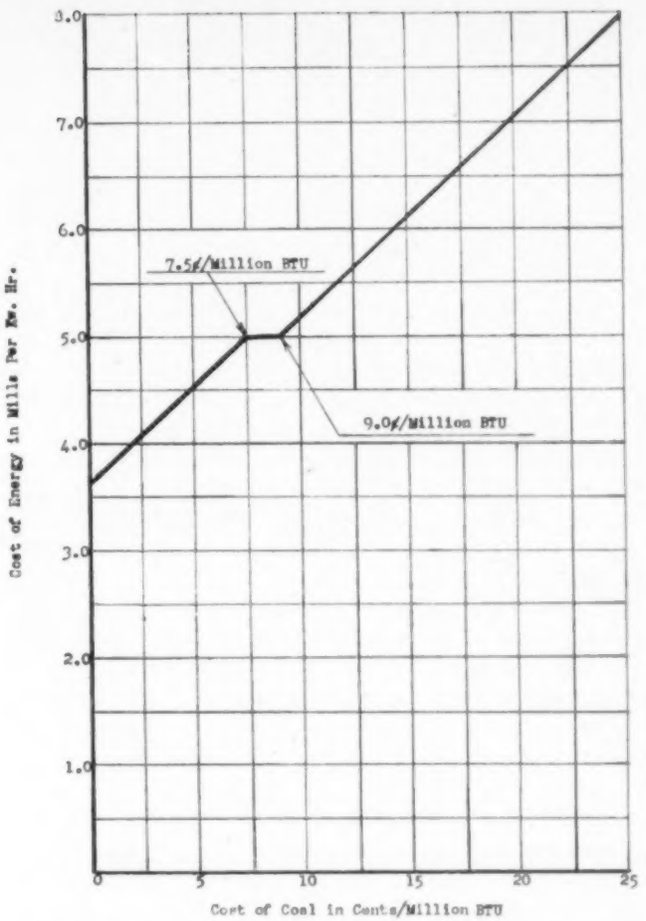


Figure 10 — Chart shows effect of fuel adjustment clause on last energy block.

one abnormal increase in load raises the customer's liability for his minimum bill from 50 per cent of the demand charge for 100 kva to the larger of (1) "50 per cent of the highest billing demand established during the previous six months" (½ of 150 = 75 kva) or to (2) $1.00 per kw for the greatest demand previously billed during the life of the contract," which in the example cited would be $150.00 instead of $100.00.

SPECIAL DISCOUNTS

Rate "W" has several special discounts available to customers who are willing or able to fulfill the special conditions which make these discounts available to them. These discounts are set forth in a series of "riders" which are available to all customers who can fulfill the conditions, on application.

These discounts are:

1. 4,000 Volt Service (Rider No. 2)—Should the customer be so located that 4,000-volt distribution lines are adjacent to his operations and if he is willing to provide his own "step down" substation, he can secure an additional discount. This discount is, however, not sufficient to make an investment in substations attractive. Unless other special conditions exist, applying for this discount is not recommended. The monthly discount for larger than 300 kva loads amount to $0.06D + $16.

2. 11,000 Volt or 22,000 Volt or 66,000 Volt Service (Rider No. 3)—Applying for this discount is not recommended for the same reasons as given for Rider No. 2, above. The amounts saved by the customer providing his own step down substation are $0.07D + $39.

3. Off Peak Service (Rider No. 5.)—Conditions for service:

a. Regular demands in excess of 300 kva.
b. Service supplied from the 11,000 volt—22,000 volt or 66,000 volt system.
c. So regulate load that large peaks occur in "Off Peak" periods (after 7.00 p.m. and before 8:00 a.m. on week days).

The utility will determine the customer's monthly bill in accordance with the lower of the following procedures.

a. The company will make a charge for only 50 per cent of the off peak demand that is in excess of the on peak demand and then calculate the bill in the usual manner.
b. The company will allow the customer as much as 100 per cent increase in his on peak demand during off peak hours but will charge for all demand in excess of 200 per cent of the on peak demand.

The kilowatt hours will then be determined for on peak service and the bill calculated in the usual manner. The kilowatt hours used during off peak hours is

also determined and sold to the customer at an additional charge of the average cost of the on peak service.

4. Temporary Service (Rider No. 6.)—Contractors or others having temporary use for electric energy at a given location can secure service under the provisions of rate "W", if he is willing to pay the regular cost of the service and in addition the cost of installing and removing any equipment such as special line extensions, transformers, circuit breakers, etc., that must be placed in service for his exclusive use. All such payments are made in advance on estimates made by the company and adjusted to the actual bill when the account is closed at the end of the service.

5. Summer Service (Rider No. 8.)—This rate is designed primarily for ice companies that have a small load over winter months which gradually builds up during the spring to a maximum for June, July, and August and then gradually diminishes through the fall to the winter minimum. There are special provisions to take care of sudden increases in demand in the middle of the month without undue demand penalties throughout the entire month. The wording of the rider is somewhat vague and needs explanation each time it is applied. The rider is only advantageous to customers of the type described. Therefore, long complicated detailed explanation of the provisions will be omitted here.

6. Municipal Off Peak Water Pumping Service (Rider No. 10.) This rider applies where municipalities take standard service from the company's 2300-volt lines, or higher for water pumping service for public water supply systems.

This rider modifies the provision for the determination of the demand by making the billing demand equal to the on peak maximum demand plus 50 per cent of the total excess of the off peak maximum demand over the on peak maximum demand, provided, however, that the billing demand shall in no case be taken at less than 50 kva.

CANCELLATION OF CONTRACT

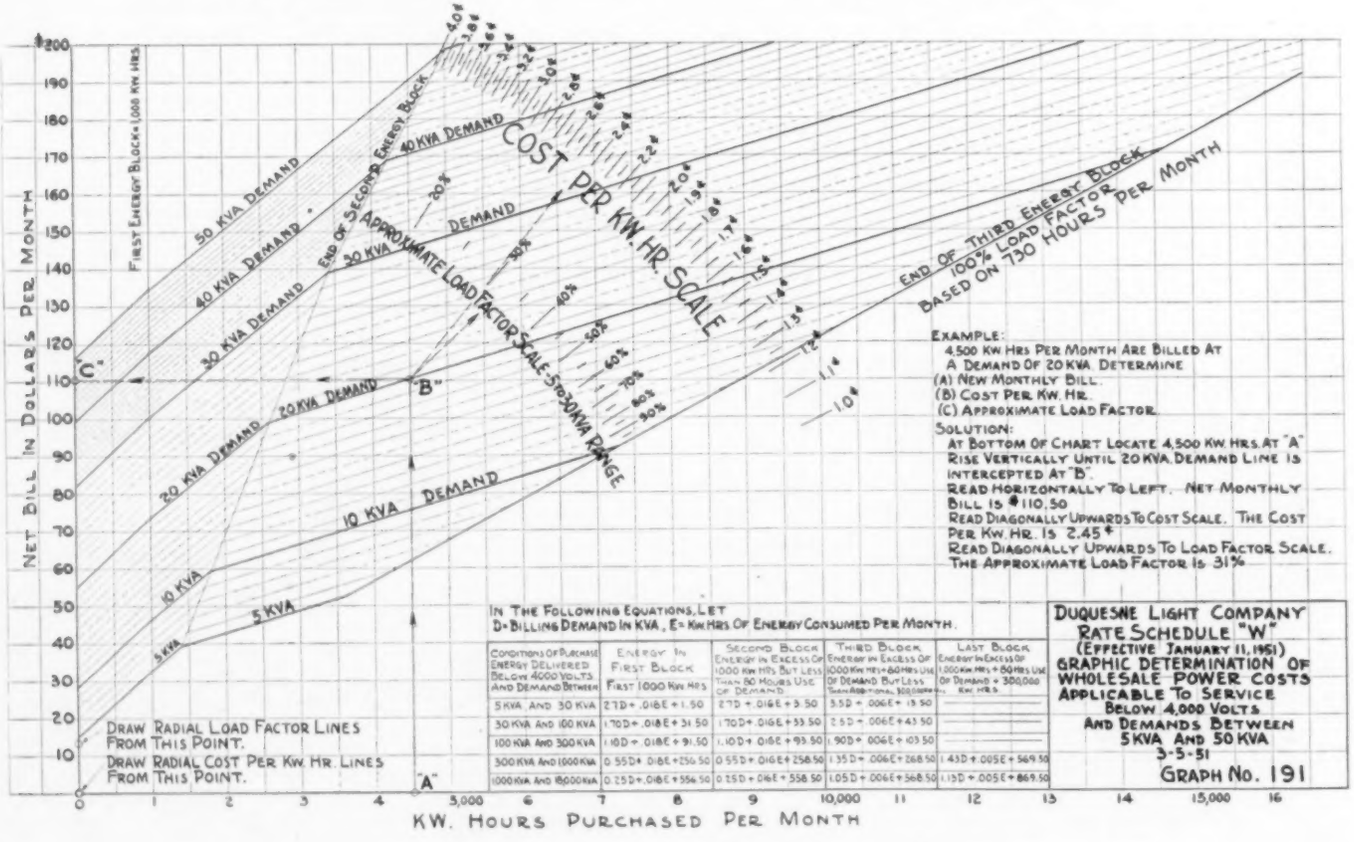
Permanent power purchasing contracts are usually made for a period of one or more years and may be cancelled on 30 days notice at any time after the expiration of the term of the original contract. This clause can be used by customers who have purchased power beyond the term of the original contract to avoid the penalties imposed by the clause calling for the minimum bill based on "50 per cent of the greatest demand charge previously billed during the life of the contract."

If the contract has run beyond the original term specified and the customer is being penalized by the minimum clause, it is only necessary to cancel the existing contract which can be done on 30 days notice and then make a new contract that will cover the customer's new conditions of operations.

COAL CLAUSE

Due to the ever-increasing cost of fuel, particularly coal, practically every public utility company developing power from steam has had to insert into its rate

Figure 11 — Chart shows rate schedule W for demands between 5 and 50 kva.


NET BILL IN DOLLARS PER MONTH
KW. HOURS PURCHASED PER MONTH
FIRST ENERGY BLOCK = 1,000 KW HRS
50 KVA DEMAND
40 KVA DEMAND
30 KVA DEMAND
20 KVA DEMAND
10 KVA DEMAND
5 KVA
END OF SECOND ENERGY BLOCK
APPROXIMATE LOAD FACTOR SCALE-5 TO 50 KVA RANGE
COST PER KW. HR. SCALE
END OF THIRD ENERGY BLOCK
100% LOAD FACTOR
BASED ON 730 HOURS PER MONTH
"A"
"B"
"C"
DRAW RADIAL LOAD FACTOR LINES FROM THIS POINT.
DRAW RADIAL COST PER KW. HR. LINES FROM THIS POINT.
EXAMPLE:
4,500 KW HRS PER MONTH ARE BILLED AT A DEMAND OF 20 KVA. DETERMINE
(A) NEW MONTHLY BILL.
(B) COST PER KW. HR.
(C) APPROXIMATE LOAD FACTOR.
SOLUTION:
AT BOTTOM OF CHART LOCATE 4,500 KW. HRS. AT "A"
RISE VERTICALLY UNTIL 20 KVA. DEMAND LINE IS INTERCEPTED AT "B".
READ HORIZONTALLY TO LEFT. NET MONTHLY BILL IS $110.50
READ DIAGONALLY UPWARDS TO COST SCALE. THE COST PER KW. HR. IS 2.45¢
READ DIAGONALLY UPWARDS TO LOAD FACTOR SCALE. THE APPROXIMATE LOAD FACTOR IS 31%
IN THE FOLLOWING EQUATIONS, LET D = BILLING DEMAND IN KVA, E = KW HRS OF ENERGY CONSUMED PER MONTH.
CONDITIONS OF PURCHASE — ENERGY DELIVERED BELOW 4000 VOLTS AND DEMAND BETWEEN
ENERGY IN FIRST BLOCK — FIRST 1000 KW HRS
SECOND BLOCK ENERGY IN EXCESS OF 1000 KW HRS BUT LESS THAN 80 HOURS USE OF DEMAND
THIRD BLOCK ENERGY IN EXCESS OF 1000 KW HRS + 80 HRS USE OF DEMAND BUT LESS THAN ADDITIONAL $60,000 KW HRS
LAST BLOCK ENERGY IN EXCESS OF 1,000 KW HRS + 80 HRS USE OF DEMAND + 300,000 KW HRS
5 KVA AND 30 KVA | 2.7D + .018E + 1.50 | 2.7D + .016E + 3.50 | 3.5D + .006E + 13.50
30 KVA AND 100 KVA | 1.70D + .018E + 31.50 | 1.70D + .016E + 33.50 | 2.5D + .006E + 43.50
100 KVA AND 300 KVA | 1.10D + .018E + 91.50 | 1.10D + .016E + 93.50 | 1.90D + .006E + 103.50
300 KVA AND 1000 KVA | 0.55D + .018E + 256.50 | 0.55D + .016E + 258.50 | 1.35D + .006E + 268.50 | 1.43D + .005E + 569.50
1000 KVA AND 15000 KVA | 0.25D + .018E + 556.50 | 0.25D + .016E + 558.50 | 1.05D + .006E + 568.50 | 1.13D + .005E + 869.50
DUQUESNE LIGHT COMPANY
RATE SCHEDULE "W"
(EFFECTIVE JANUARY 11, 1951)
GRAPHIC DETERMINATION OF WHOLESALE POWER COSTS APPLICABLE TO SERVICE BELOW 4,000 VOLTS AND DEMANDS BETWEEN 5 KVA AND 50 KVA
3-5-51
GRAPH NO. 191

schedule a "coal clause." Figure 10 is a graphic illustration of the Duquesne Light Co. "coal clause." This clause is based on a "cost per million Btu of fuel."

Should the cost of fuel vary between the limits of 7½¢ and 9.0¢ per million Btu, no adjustment in the cost of the kwhr will be made. If, however, the cost per million Btu varies beyond this range, an adjustment in the price charged for each block of energy (except the first 1,000 kwhr purchased each month, which is exempt) will be made.

Figure 10 shows the change in the cost of energy in the last or 0.5¢ block. All other blocks except the first would change by the same amount. For example, if the cost of fuel went up to 20¢ per million Btu, the cost of energy in the last block would be 7 mills per kwhr instead of 5 mills per kwhr, as shown in the rate.

APPENDIX NO. 1

Explanation of Graphic Charts No. 191, 192, 193, and 194.

Rate schedule "W" of the Duquesne Light Co. can be shown in graphic form, and when presented in this manner, it illustrates the essential elements of the rate that enter into the cost of power. Formulae are shown on the graph which when properly applied, will give the exact bill for the energy purchased.

In the graphs the "Cost of Energy in Dollars per Month" is used as the vertical ordinate and "Kwhr Purchased per Month" is used as the horizontal ordinate. A family of lines on the graph aids in the quick and easy determination of the electric bill for any demand and any number of kwhr purchased within the limits covered by the charts.

Inasmuch as the utility company allows only a small discount for customer ownership of the substation, it does not pay a customer to own his substation; therefore, only those graphs showing cost of service where the customer purchases energy below 4000 volts will be given. Formulae are shown on each graph giving the amount to be subtracted if the higher voltage discounts are applicable. Figure 11, graph No. 191 shows the cost of energy per month for demands between 5 and 50 kva.

Figure 12, graph No. 192, shows the cost of energy per month for demands between 30 kva and 900 kva.

Figure 13, graph No. 193, shows the cost of energy per month for demands between 300 kva and 2000 kva.

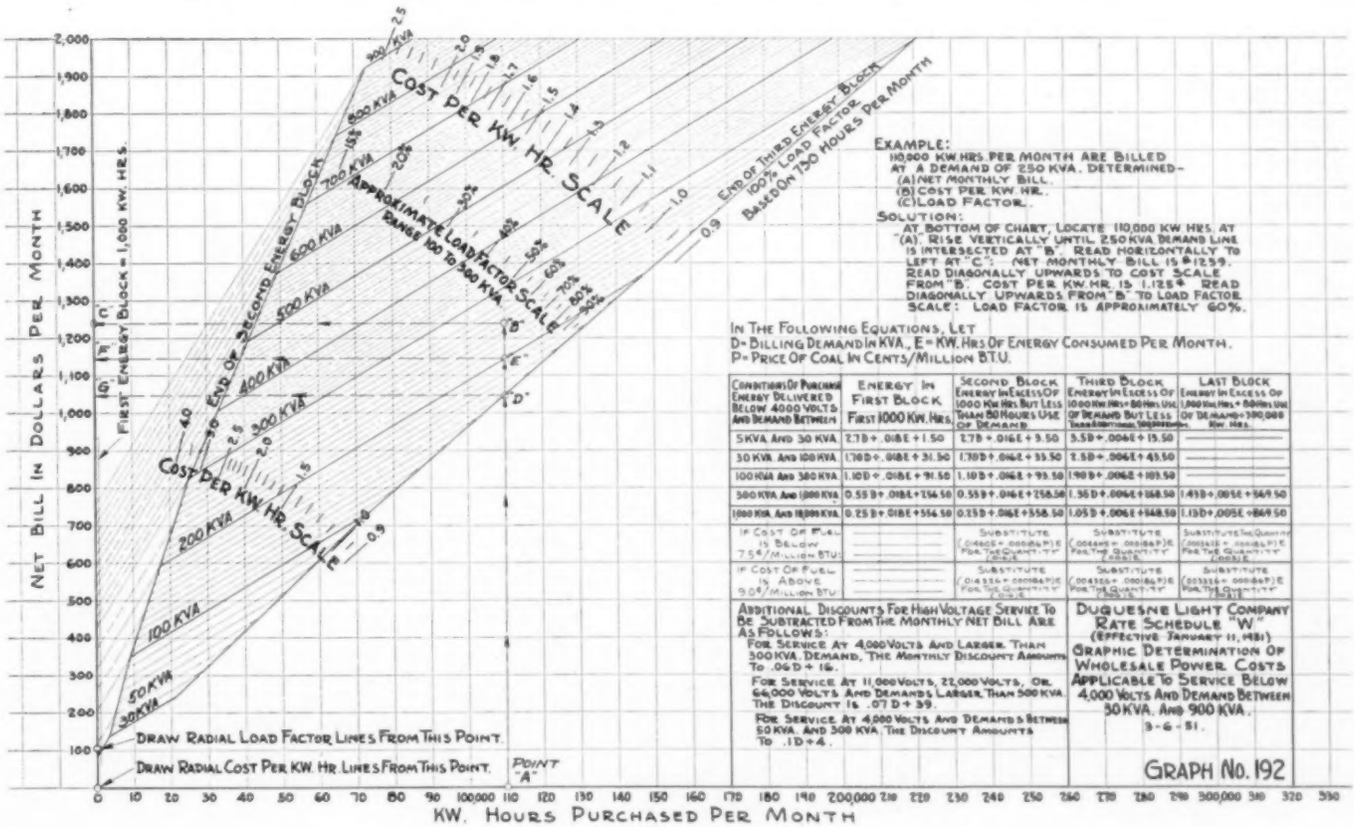
Figure 14, graph No. 194, shows the cost of energy per month for demands between 1000 kva and 20,000 kva in the last energy block.

These four charts cover all of the purchases made by consumers who purchase power under this rate.

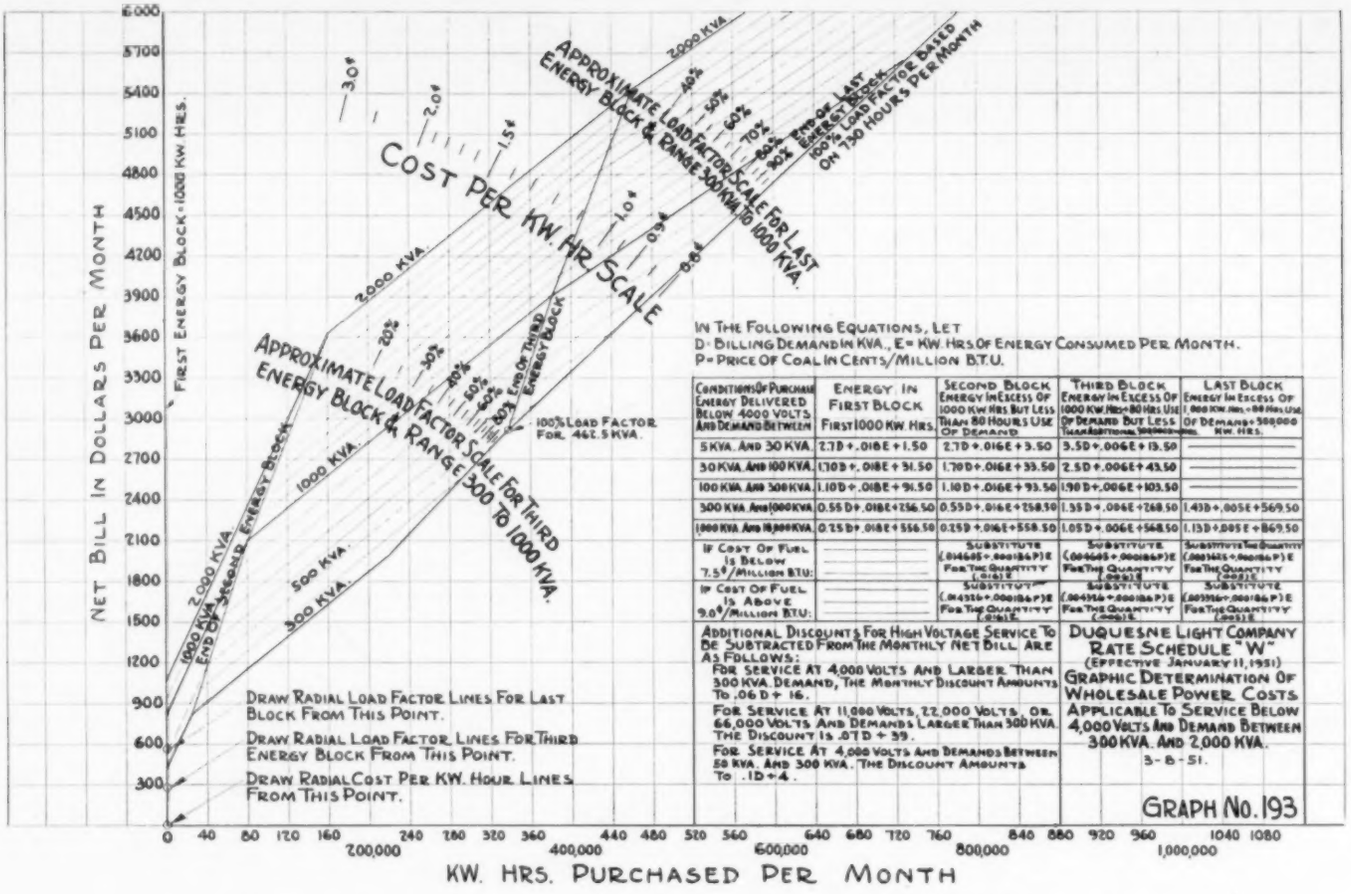
The principal object sought, when purchasing electric energy is to supply power for definite industrial operations. The purchase of this energy can be made at low rates if the user is careful and understands the conditions which impose penalties and raise the cost of power unnecessarily, but if this same user is careless or if the conditions are not fully understood, the power required to meet industrial requirements may become unnecessarily expensive.

The second object can, therefore, be stated to be the purchase of the power necessary for operations at the

Figure 12 — Chart shows rate schedule W for demands between 30 and 900 kva.


NET BILL IN DOLLARS PER MONTH
KW. HOURS PURCHASED PER MONTH
COST PER KW. HR. SCALE
APPROXIMATE LOAD FACTOR SCALE RANGE 100 TO 900 KVA
FIRST ENERGY BLOCK = 1,000 KW. HRS.
END OF SECOND ENERGY BLOCK
END OF THIRD ENERGY BLOCK 100% LOAD FACTOR BASED ON 730 HOURS PER MONTH
DRAW RADIAL LOAD FACTOR LINES FROM THIS POINT.
DRAW RADIAL COST PER KW. HR. LINES FROM THIS POINT.
POINT "A"
EXAMPLE:
110,000 KW HRS PER MONTH ARE BILLED AT A DEMAND OF 250 KVA. DETERMINED-
(A) NET MONTHLY BILL.
(B) COST PER KW. HR.
(C) LOAD FACTOR.
SOLUTION:
AT BOTTOM OF CHART, LOCATE 110,000 KW HRS. AT "(A)". RISE VERTICALLY UNTIL 250 KVA DEMAND LINE IS INTERSECTED AT "B". READ HORIZONTALLY TO LEFT AT "C": NET MONTHLY BILL IS $ 1259.
READ DIAGONALLY UPWARDS TO COST SCALE FROM "B". COST PER KW. HR. IS 1.125¢ READ DIAGONALLY UPWARDS FROM "B" TO LOAD FACTOR SCALE: LOAD FACTOR IS APPROXIMATELY 60%.
IN THE FOLLOWING EQUATIONS, LET
D = BILLING DEMAND IN KVA., E = KW. HRS OF ENERGY CONSUMED PER MONTH.
P = PRICE OF COAL IN CENTS/MILLION BTU.
ADDITIONAL DISCOUNTS FOR HIGH VOLTAGE SERVICE TO BE SUBTRACTED FROM THE MONTHLY NET BILL ARE AS FOLLOWS:
FOR SERVICE AT 4,000 VOLTS AND LARGER THAN 300 KVA. DEMAND, THE MONTHLY DISCOUNT AMOUNTS TO .06D + 16.
FOR SERVICE AT 11,000 VOLTS, 22,000 VOLTS, OR 66,000 VOLTS AND DEMANDS LARGER THAN 500 KVA. THE DISCOUNT IS .07D + 39.
FOR SERVICE AT 4,000 VOLTS AND DEMANDS BETWEEN 50 KVA. AND 300 KVA. THE DISCOUNT AMOUNTS TO .1D + 4.
DUQUESNE LIGHT COMPANY
RATE SCHEDULE "W"
(EFFECTIVE JANUARY 11, 1951)
GRAPHIC DETERMINATION OF WHOLESALE POWER COSTS APPLICABLE TO SERVICE BELOW 4,000 VOLTS AND DEMAND BETWEEN 30 KVA. AND 900 KVA.
9-6-51.
GRAPH No. 192

CONDITIONS OF PURCHASE ENERGY DELIVERED BELOW 4000 VOLTS AND DEMAND BETWEEN	ENERGY IN FIRST BLOCK. FIRST 1000 KW. HRS.	SECOND BLOCK ENERGY IN EXCESS OF 1000 KW. HRS. BUT LESS THAN 80 HOURS USE OF DEMAND	THIRD BLOCK ENERGY IN EXCESS OF 1000 KW. HRS + 80 HRS. USE OF DEMAND BUT LESS THAN ADDITIONAL 190 HOURS USE OF DEMAND	LAST BLOCK ENERGY IN EXCESS OF 1,000 KW. HRS + 270 HRS. USE OF DEMAND = 190,000 KW. HRS.
5 KVA AND 30 KVA	2.7D + .018E + 1.50	2.7D + .016E + 9.50	3.5D + .006E + 15.50	
30 KVA AND 100 KVA	1.10D + .018E + 31.50	1.10D + .016E + 93.50	2.50 + .006E + 43.50	
100 KVA AND 500 KVA	0.55D + .018E + 154.50	0.55D + .016E + 258.50	1.35D + .006E + 168.50	1.43D + .005E + 369.50
1000 KVA AND 19,000 KVA	0.25D + .018E + 554.50	0.25D + .016E + 358.50	1.05D + .006E + 448.50	1.13D + .005E + 869.50
IF COST OF FUEL IS BELOW 7.5¢/MILLION BTU:		SUBSTITUTE (.004556 + .000186P)E FOR THE QUANTITY .016E	SUBSTITUTE (.004556 + .000186P)E FOR THE QUANTITY .006E	SUBSTITUTE THE QUANTITY (.003336 + .000186P)E FOR THE QUANTITY .005E
IF COST OF FUEL IS ABOVE 9.0¢/MILLION BTU:		SUBSTITUTE (.014556 + .000186P)E FOR THE QUANTITY .016E	SUBSTITUTE (.004556 + .000186P)E FOR THE QUANTITY .006E	SUBSTITUTE (.003336 + .000186P)E FOR THE QUANTITY .005E

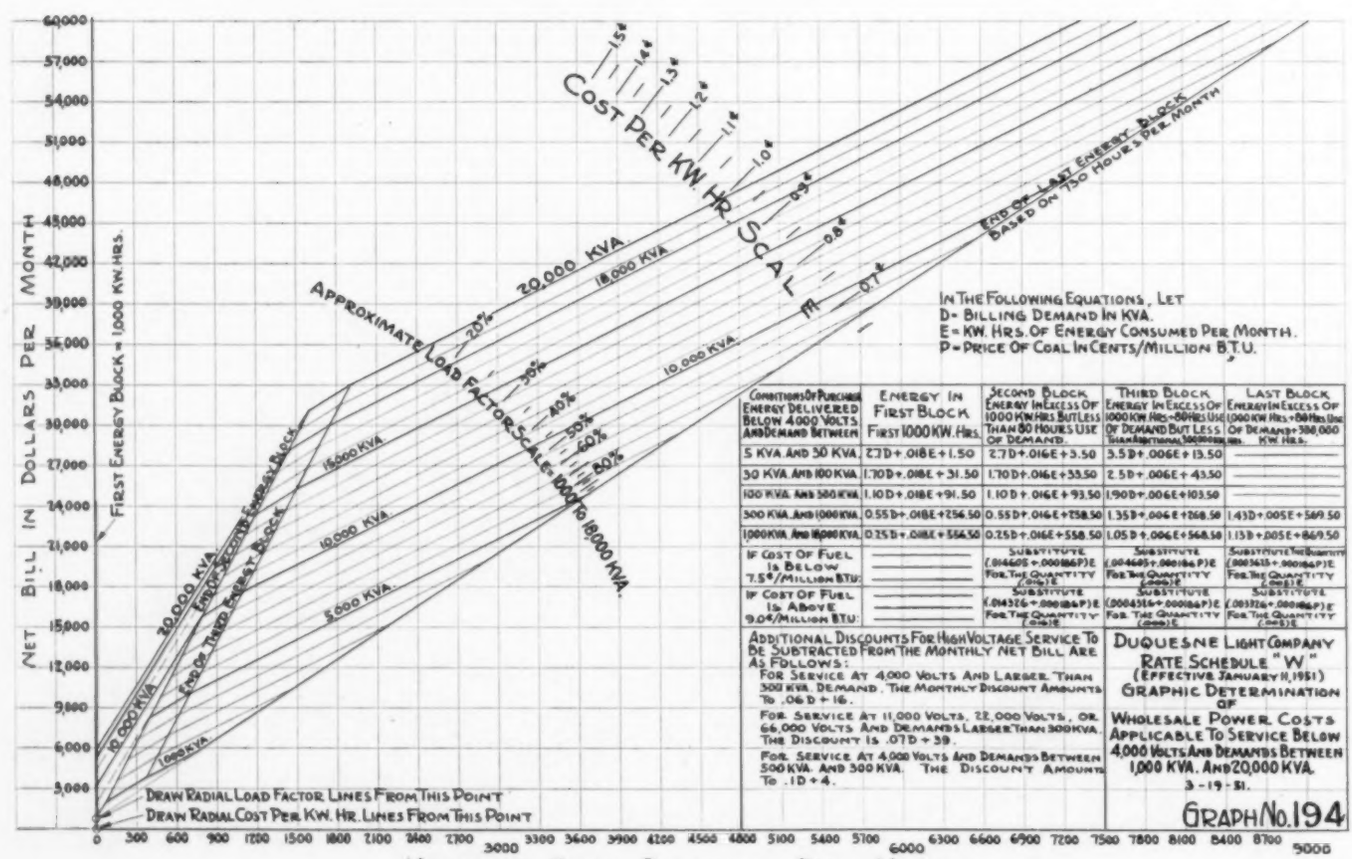

NET BILL IN DOLLARS PER MONTH
FIRST ENERGY BLOCK = 1000 KW. HRS.
COST PER KW. HR. SCALE
APPROXIMATE LOAD FACTOR SCALE FOR LAST ENERGY BLOCK & RANGE 300 KVA TO 1000 KVA.
APPROXIMATE LOAD FACTOR SCALE FOR THIRD ENERGY BLOCK & RANGE 300 TO 1000 KVA.
END OF LAST ENERGY BLOCK BASED ON 730 HOURS PER MONTH
END OF THIRD ENERGY BLOCK
100% LOAD FACTOR FOR 462.5 KVA.
2000 KVA.
1000 KVA.
500 KVA.
300 KVA.
DRAW RADIAL LOAD FACTOR LINES FOR LAST BLOCK FROM THIS POINT.
DRAW RADIAL LOAD FACTOR LINES FOR THIRD ENERGY BLOCK FROM THIS POINT.
DRAW RADIAL COST PER KW. HOUR LINES FROM THIS POINT.
IN THE FOLLOWING EQUATIONS, LET
D = BILLING DEMAND IN KVA., E = KW. HRS. OF ENERGY CONSUMED PER MONTH.
P = PRICE OF COAL IN CENTS/MILLION B.T.U.
DUQUESNE LIGHT COMPANY
RATE SCHEDULE "W"
(EFFECTIVE JANUARY 11, 1951)
GRAPHIC DETERMINATION OF WHOLESALE POWER COSTS APPLICABLE TO SERVICE BELOW 4,000 VOLTS AND DEMAND BETWEEN 300 KVA. AND 2,000 KVA.
3-8-51.
GRAPH No. 193
KW. HRS. PURCHASED PER MONTH

Conditions Of Purchase Energy Delivered Below 4000 Volts And Demand Between	Energy In First Block First 1000 KW. Hrs.	Second Block Energy In Excess Of 1000 KW Hrs But Less Than 80 Hours Use Of Demand	Third Block Energy In Excess Of 1000 KW Hrs + 80 Hrs Use Of Demand But Less Than Additional 300,000 KW. Hrs.	Last Block Energy In Excess Of (1,000 KW. Hrs. + 80 Hrs. Use Of Demand + 300,000 KW. Hrs.
5 KVA. And 30 KVA.	2.7D + .018E + 1.50	2.7D + .016E + 3.50	3.5D + .006E + 13.50	
30 KVA. And 100 KVA.	1.70D + .018E + 31.50	1.70D + .016E + 33.50	2.5D + .006E + 43.50	
100 KVA. And 500 KVA.	1.10D + .018E + 91.50	1.10D + .016E + 93.50	1.90D + .006E + 103.50	
500 KVA. And 1000 KVA.	0.55D + .018E + 256.50	0.55D + .016E + 258.50	1.35D + .006E + 268.50	1.43D + .005E + 569.50
1000 KVA. And 18000 KVA.	0.25D + .018E + 556.50	0.25D + .016E + 558.50	1.05D + .006E + 568.50	1.13D + .005E + 869.50
If Cost Of Fuel Is Below 7.5¢/Million BTU:		Substitute (.014605 + .000186P)E For The Quantity (.016)E	Substitute (.004605 + .000186P)E For The Quantity (.006)E	Substitute The Quantity (.003615 + .000186P)E For The Quantity (.005)E
If Cost Of Fuel Is Above 9.0¢/Million BTU:		Substitute (.014326 + .000186P)E For The Quantity (.016)E	Substitute (.004326 + .000186P)E For The Quantity (.006)E	Substitute (.003326 + .000186P)E For The Quantity (.005)E

ADDITIONAL DISCOUNTS FOR HIGH VOLTAGE SERVICE TO BE SUBTRACTED FROM THE MONTHLY NET BILL ARE AS FOLLOWS:
FOR SERVICE AT 4,000 VOLTS AND LARGER THAN 300 KVA. DEMAND, THE MONTHLY DISCOUNT AMOUNTS TO .06 D + 16.
FOR SERVICE AT 11,000 VOLTS, 22,000 VOLTS, OR 66,000 VOLTS AND DEMANDS LARGER THAN 300 KVA. THE DISCOUNT IS .07 D + 39.
FOR SERVICE AT 4,000 VOLTS AND DEMANDS BETWEEN 50 KVA. AND 300 KVA. THE DISCOUNT AMOUNTS TO .1 D + 4.

Figure 13 — Chart shows rate schedule W for demands between 300 and 2000 kva.

Figure 14 — Chart shows rate schedule W for demands between 1000 and 20,000 kva.


NET BILL IN DOLLARS PER MONTH
FIRST ENERGY BLOCK = 1,000 KW. HRS.
COST PER KW. HR. SCALE
APPROXIMATE LOAD FACTOR SCALE = 100% TO 18,000 KVA.
END OF LAST ENERGY BLOCK BASED ON 730 HOURS PER MONTH
END OF SECOND ENERGY BLOCK
END OF THIRD ENERGY BLOCK
20,000 KVA.
18,000 KVA.
15,000 KVA.
10,000 KVA.
5,000 KVA.
1,000 KVA.
DRAW RADIAL LOAD FACTOR LINES FROM THIS POINT
DRAW RADIAL COST PER KW. HR. LINES FROM THIS POINT
IN THE FOLLOWING EQUATIONS, LET
D = BILLING DEMAND IN KVA.
E = KW. HRS. OF ENERGY CONSUMED PER MONTH.
P = PRICE OF COAL IN CENTS/MILLION B.T.U.
DUQUESNE LIGHT COMPANY
RATE SCHEDULE "W"
(EFFECTIVE JANUARY 11, 1951)
GRAPHIC DETERMINATION OF WHOLESALE POWER COSTS APPLICABLE TO SERVICE BELOW 4,000 VOLTS AND DEMANDS BETWEEN 1,000 KVA. AND 20,000 KVA.
3-19-51.
GRAPH No. 194
MEGAWATT HOURS PURCHASED PER MONTH

Conditions Of Purchase Energy Delivered Below 4000 Volts And Demand Between	Energy In First Block First 1000 KW. Hrs.	Second Block Energy In Excess Of 1000 KW Hrs But Less Than 80 Hours Use Of Demand	Third Block Energy In Excess Of 1000 KW Hrs + 80 Hrs Use Of Demand But Less Than Additional 300,000 KW. Hrs.	Last Block Energy In Excess Of (1,000 KW. Hrs. + 80 Hrs. Use Of Demand + 300,000 KW. Hrs.
5 KVA. And 30 KVA.	2.7D + .018E + 1.50	2.7D + .016E + 3.50	3.5D + .006E + 13.50	
30 KVA. And 100 KVA.	1.70D + .018E + 31.50	1.70D + .016E + 33.50	2.5D + .006E + 43.50	
100 KVA. And 500 KVA.	1.10D + .018E + 91.50	1.10D + .016E + 93.50	1.90D + .006E + 103.50	
500 KVA. And 1000 KVA.	0.55D + .018E + 256.50	0.55D + .016E + 258.50	1.35D + .006E + 268.50	1.43D + .005E + 569.50
1000 KVA. And 18000 KVA.	0.25D + .018E + 556.50	0.25D + .016E + 558.50	1.05D + .006E + 568.50	1.13D + .005E + 869.50
If Cost Of Fuel Is Below 7.5¢/Million BTU:		Substitute (.014605 + .000186P)E For The Quantity (.016)E	Substitute (.004605 + .000186P)E For The Quantity (.006)E	Substitute The Quantity (.003615 + .000186P)E For The Quantity (.005)E
If Cost Of Fuel Is Above 9.0¢/Million BTU:		Substitute (.014326 + .000186P)E For The Quantity (.016)E	Substitute (.004326 + .000186P)E For The Quantity (.006)E	Substitute (.003326 + .000186P)E For The Quantity (.005)E

ADDITIONAL DISCOUNTS FOR HIGH VOLTAGE SERVICE TO BE SUBTRACTED FROM THE MONTHLY NET BILL ARE AS FOLLOWS:
FOR SERVICE AT 4,000 VOLTS AND LARGER THAN 300 KVA. DEMAND, THE MONTHLY DISCOUNT AMOUNTS TO .06 D + 16.
FOR SERVICE AT 11,000 VOLTS, 22,000 VOLTS, OR 66,000 VOLTS AND DEMANDS LARGER THAN 300 KVA. THE DISCOUNT IS .07 D + 39.
FOR SERVICE AT 4,000 VOLTS AND DEMANDS BETWEEN 500 KVA. AND 300 KVA. THE DISCOUNT AMOUNTS TO .1 D + 4.

lowest possible cost consistent with proper operations.

A careful study of Schedule "W" shows that the principal item which should be watched is the "Demand." Any item which tends to raise or lower the demand will have a major effect on the power bill.

As an example of the effect of the demand, expressed in terms of actual money, suppose a consumer purchased 110,000 kwhr of energy in a month at a billing demand of 250 kva. By referring to Figure 12 and reading along the bottom line to 110,000 kwhr (indicated at "A") for a starting point, move vertically upward along the heavy dotted line as indicated by arrow heads until the 250 kva demand line is intersected at "B", then move horizontally to the left as indicated by the arrow heads until, at the left margin the monthly power bill is found to be approximately $1,239.00, as shown at "C." Suppose the management were able to rearrange the operations of this consumer so that the same quantity of energy could be purchased under almost perfect conditions approaching 100 per cent load factor. The demand would then drop from 250 kva, shown at "B," to 150.7 kva, as shown at "D," and the monthly bill for the same number of kwhr under this last condition would drop from $1,239.00, as shown at "C," to approximately $1,047.00, as shown at "G," thereby making a saving of $192.00 a month.

It might be well to explain here that the perfect use of electric energy by any consumer is almost, if not quite, impossible, as, in general, the perfect use represents a consumption of energy at an absolutely uniform rate for 24 hours a day and 30 days a month; but if, in his attempts to approach this perfect condition, he reduces his demand from 250 kva to 200 kva, as shown at "E," which in many cases would be entirely practical, he has reduced his cost of electric energy from $1,239.00 a month, as shown at "C," to $1,142.00 a month, as shown at "F." This last represents a saving of $97.00 a month and is worth while expending a little effort and care to realize.

Another way of stating this example would be to state that under the conditions of 250 kva of demand the customer actually paid $1,047 a month for the energy used and $192 a month as a penalty for irregular use and for the creation of high peaks.

In the foregoing illustration, no attempt was made to reduce the number of kwhr of energy consumed. In all cases the customer used 110,000 kwhr during the month.

The saving was accomplished by so regulating the time of the energy consumption that the heavy peak loads were "staggered" and did not occur simultaneously. It is the simultaneous occurrence of heavy loads that raise the demand charges in most electric bills. The reason for this is that the number of kwhr used by a consumer (unless absolute waste is allowed) is usually very closely associated with the production or the volume of business done and this production or volume of business done is closely associated with the profit derived from the business. Any economy that resulted in reduced profits would usually be "false economy."

Figures 13 and 14 are given for use in studying power bills under rate schedule "W" where the kwhr purchased and the demands involved exceed the limits of Figure 12.

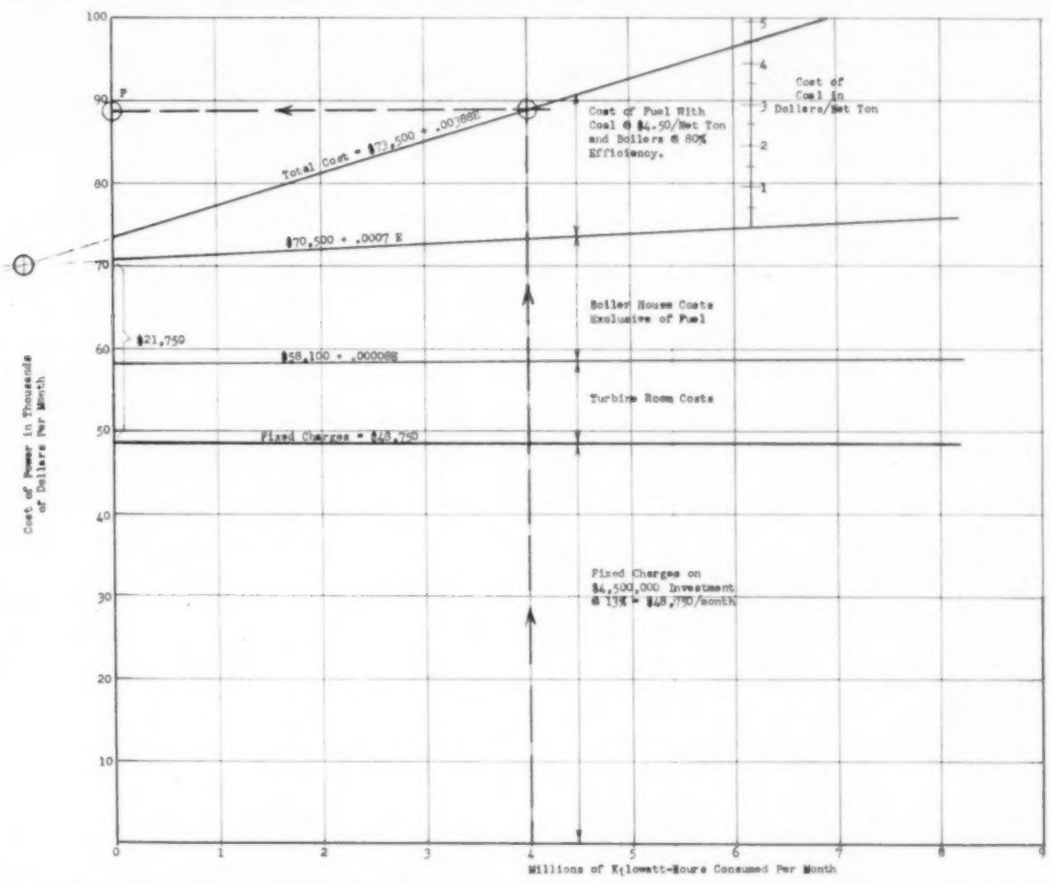

Cost of Power in Thousands of Dollars Per Month
Millions of Kilowatt-Hours Consumed Per Month
Cost of Fuel With Coal @ $4.50/Net Ton and Boilers @ 80% Efficiency.
Cost of Coal in Dollars/Net Ton
Total Cost = $72,500 + .00188E
$70,500 + .0007 E
Boiler House Costs Exclusive of Fuel
$21,750
$58,100 + .000088E
Turbine Room Costs
Fixed Charges = $48,750
Fixed Charges on $4,500,000 Investment @ 13% = $48,750/month
P

Figure 15 — Chart shows cost of operating an isolated 15,000-kw coal-fired generating station with a boiler efficiency of 80 per cent and coal costs of $4.50 per net ton.

It is often said that concerns having large loads can generate their own power from coal more economically than they can purchase power from a utility company that has long transmission lines to maintain, with the investment charges, transmission losses, and maintenance charges incident to these long lines. In order to consider this point, the author has chosen at random to set up typical costs for a hypothetical manufacturing plant having what the plant engineer would consider a 9000-kw demand.

It would seem to be reasonably good engineering to install two 5000-kw generators for service, and, inasmuch as the plant is isolated, a third 5000-kw unit as a spare. The plant would probably install three boilers. A station of comparatively small units of this kind, if the land values, sewers, intake, pumps and pump-house costs were included, would probably cost at least $300.00 per kilowatt of installed generator capacity, making a total investment of $4,500,000 in the station. If fixed charges of 13 per cent are placed against the station, the monthly fixed charges would be approximately $48,750.

With an average year-around boiler efficiency of 80 per cent, a reasonable steam rate on the turbine, and coal at $4.50 per net ton, the cost of operating such a station would be fairly well represented by Figure 15. In this figure, the cost of power in dollars per month is plotted as the vertical ordinate, and the energy produced as the horizontal ordinate. The total cost of power could be divided into two parts—a constant cost which is independent of the production, and an increment cost which, within certain limits, is directly proportional to the production. Figure 15 shows that at any load L the total cost of power would be shown at P as indicated by the arrow and dotted lines.

In this particular case, the constant cost of power is $73,500 a month, including fixed charges of $48,750 a month, and constant operating costs of $21,750 a month. In order to obtain the total cost of energy for the month, it is necessary to add the increment cost of 3.88 mills for each kilowatt-hour produced.

In order to compare the cost of purchased power with power generated in a privately owned station, the upper cost line of Figure 15 is repeated in Figure 16, to which has been added the cost of electric energy purchased under the schedule that has been considered, based on a 9000-kw measured demand.

To make all conditions reasonable and comparable, a 75 per cent power-factor has been used. This is quite usual in the smaller generating plants. Because of this power factor, the measured demand of 9000 kw is raised to a billing demand of 12,000 kilovolt-amperes on rate schedule "W."

Figure 16 shows a number of very interesting facts: (1) that the so-called high-cost, low-load-factor, public utility power is in reality cheap power, if compared with the cost of producing the same energy in a private station; (2) that under any reasonable operating conditions, the schedule considered offers energy to a customer for less money than he can build and operate his own station; (3) in schedule "W" the rates are below the cost of the private station throughout the entire range of all possible loads.

These facts are true only when a private station is

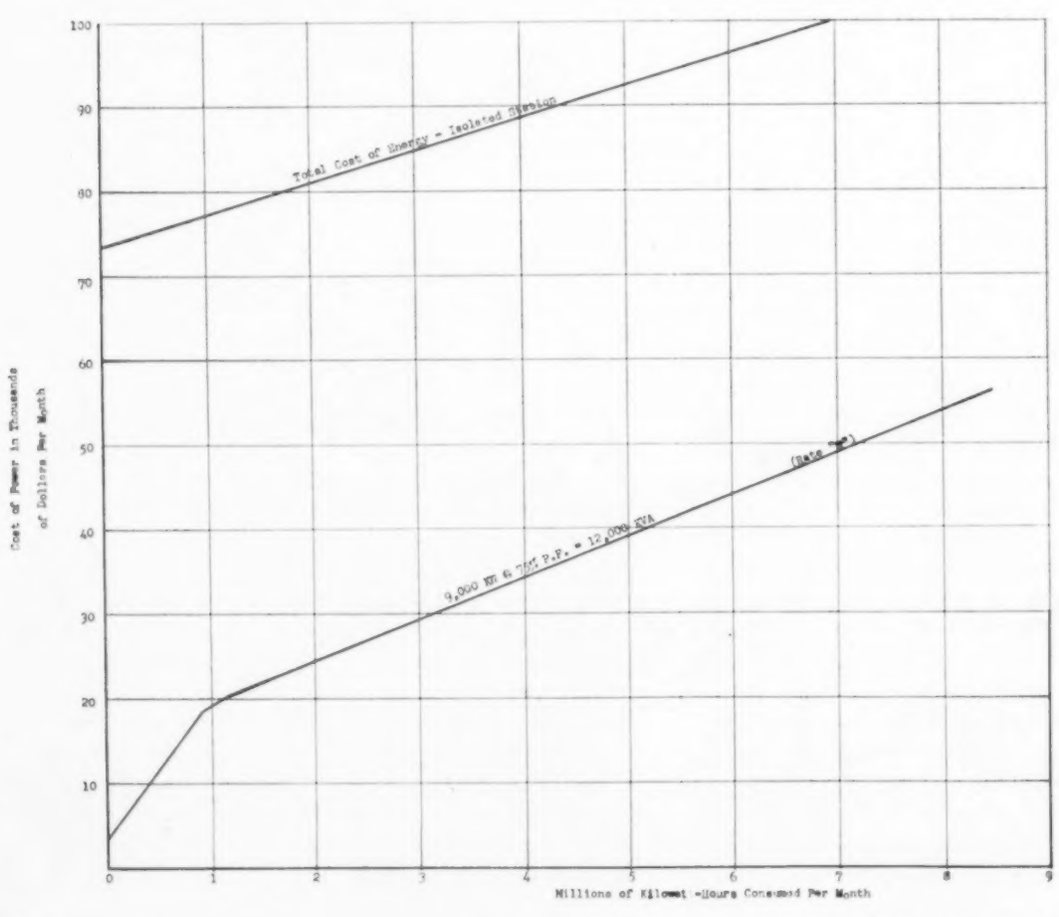


Figure 16—Chart shows cost comparison for operating one small isolated power station with purchased public utility power. Isolated station has three 5000-kva turbogenerators. Utility company is assumed to have a 9000-kw load at 75 per cent power factor, equivalent to billing demand of 12,000 kva.

built solely for the purpose of generating electric energy, and when the price of coal is as stated—$4.50 per net ton. Cheaper coal would not materially affect the constant part of the costs, but would affect the increment costs by flattening the slope of the cost line.

If large quantities of steam are needed for process work, or if large quantities of by-product heat are available, which if not turned into other forms of useful energy must be dissipated at its source, the situation is entirely changed and an almost infinite variety of possibilities and conditions presents itself. Each case of this kind must be examined and decided upon its own merits.

In closing, attention is called to one very common error, often made when comparing the cost of purchased electric energy with that generated in the consumer's privately owned and operated power station.

The cost sheets of practically every manufacturing company show only the operating costs for the plant or department under consideration, and fail to take into account the fixed charges which cover interest, depreciation, amortization, taxes, etc. Inasmuch as these items are real costs, the public utility rates must of necessity include them in their schedules. The average purchaser of power looks only at his cost sheets and compares the cost of power as shown, with the amount of money he must pay a power company for the same quantity of energy, thereby completely losing sight of the fixed-charge item which does not appear on his own cost sheets. Such a comparison is obviously unfair and frequently leads to erroneous decisions. Furthermore, when money is once invested in a privately owned power plant, the assets become frozen and cannot be liquidated at anything like par value, except by the continued use of the equipment during its normal operating period or life. While the same charges are paid to a power company, the consumer is called upon to pay for only that part of the equipment which he actually uses, and he avoids fixed charges on idle equipment held as spares, which he would have in his own power house.

If, for any reason, he decides to cancel his contract with the power company at any time prior to the completion of the period of normal life of a power house which he might have installed, his fixed charges cease and his investment is liquidated at full par value at once and without effort on his part. It, therefore, appears to the writer that even with large loads, there are very few manufacturers who can afford to install a straight coal-fired power station for the generation of electric energy in competition with power rates such as we have examined in this paper, unless the manufacturer has power as a by-product incidental to other manufacturing processes.

DISCUSSION

PRESENTED BY

M. R. McCONNELL, West Penn Power Co., Pittsburgh, Pa.

W. B. SKINKLE, Consulting Engineer, Pittsburgh, Pa.

M. R. McConnell: I like the "Willins Line" type of graph, because it covers all phases of power generation cost and shows the effect of load factor in its true light. For example, you will note from Mr. Skinkle's Figure 15 that the monthly total cost at 1,000,000 kwhr use is $77,000 and for another month with nearly full operation of 6,000,000 kwhr is $96,000, or a difference of only $19,000 between light load and full load operation of the plant. As Mr. Skinkle has pointed out, there are two constant costs—fixed charges and constant operating costs, which amount to about 70 per cent, or you can say that only 30 per cent of the total costs are variable. This is important for management to know before it assumes such an obligation.

I have had the opportunity of comparing this curve with the one Mr. Skinkle drew in 1929. Some very interesting changes have taken place. Here is what I found. The fixed charge portion of the generating cost is now 240 per cent of 1929, because of the increased cost of equipment and construction. The constant operating cost is 270 per cent of 1929, because of increased cost of labor, materials and supplies. The variable costs are less even though the cost of fuel used is 30 per cent higher. This reflects the increased efficiencies of new equipment, higher steam pressures and temperatures. In other words, the slope of the top line is less although the total cost is much higher. This means there is less change in cost between no load and full load operation. In the meantime, purchased power cost dropped during the 1930's and recently has returned to substantially the same level as 1929, with the result that generated cost is approximately double that of purchased cost as shown in Mr. Skinkle's Figure 16.

This increased spread undoubtedly is one of the reasons for the large growth in utility power loads and the drastic reduction in the number of new private generating plants being installed.

Mr. Skinkle points out, however, that where there are complicating factors such as by-product heat or process steam uses, the situation may be changed and each case should be examined on its own merits.

For example, let us suppose there is a source of blast furnace gas and coke breeze that can be used. Looking at Mr. Skinkle's Figure 15, and assuming an equivalent value for the gas or fuel of $1.00 per ton, or 3.8¢ per MBtu, the cost of generation is reduced, the curve becomes flatter and about $16,000 is taken off the total cost. Still, it is not near the purchased power curve.

It would appear that if the blast furnace gas and the coke breeze are to be utilized economically, some method of reducing capital costs and the consequent fixed charges are necessary.

The chief method of reducing the large item of capital investment is to increase the size of the individual units in a power plant, use bigger boilers and bigger turbines. For instance, Mr. Skinkle used a cost of $300/kw for 5000-kw units. The cost would be $200/kw for 20,000 kw units, $150/kw for 80,000 kw units and $140/kw for 100,000 kw units.

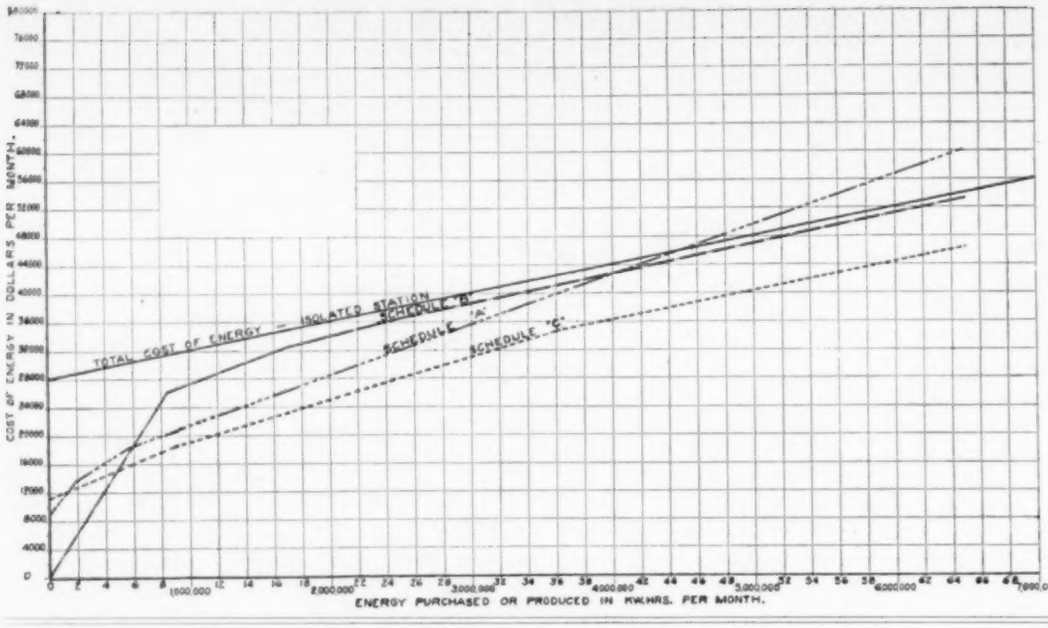

COST OF ENERGY IN DOLLARS PER MONTH.
TOTAL COST OF ENERGY — ISOLATED STATION
SCHEDULE "B"
SCHEDULE "A"
SCHEDULE "C"
ENERGY PURCHASED OR PRODUCED IN KW.HRS. PER MONTH.

Figure 17—Chart shows cost of producing energy in 15,000-kw isolated coal-fired generating station compared with cost of purchasing electric energy from local public utilities at a measured demand of 9000 kw at 75 per cent power factor. Data for this chart are based on 1929 costs. Note that here purchased power and home generated power are competitive. Compare with Figure 16 where this situation is no longer true.

Obviously, as the size of the power plant increases, the relative size of the fixed charge item decreases. However, the size of units that can be installed is limited by the by-product fuel available and the ability of the plant to utilize the power generated.

While it is possible to reduce capital investment by the use of larger units, the question of return on the investment needs further scrutiny.

In his computation Mr. Skinkle has used 13 per cent for fixed charges. The recent impact of federal taxes has caused public utilities to use a figure of 15-16 per cent. This figure includes a 6 per cent net return on the investment. However, steel companies generally earn 14-20 per cent net return on plant investment and fabricating plants, such as automobile manufacturers earn from 40-80 per cent. There are so many needs for money today that a prudent management will be reluctant to invest in power generating equipment, if that investment does not produce an equivalent return. Even if an industrial management were reconciled to a return of 12 per cent on the money invested for service facilities, the fixed charges after taking into account the impact of federal income and excess profits taxes, would be in the order of 30 per cent, or approximately double the figure used by utilities and the figure used by Mr. Skinkle. If these higher fixed charges must be recognized, it then seems obvious that there is no economic benefit to be obtained from the use of by-product fuel for power generation. This seems to indicate the need for another method of disposal of this by-product fuel. Can it be used to better advantage for other heat processes especially those requiring less capital investment?

When process steam is required in a manufacturing plant, it is sometimes felt that the steam need will justify a private generating plant. Again, the item of fixed charges carries the key to the answer. A steam plant built to provide process steam only, is generally designed for the approximate pressure of utilization. A joint steam and power generation plant requires a higher pressure and temperature boiler plant to give the desired heat balance. Also, the boiler for joint use must be at least 15 per cent larger. Obviously, the simple steammaking unit will cost considerably less.

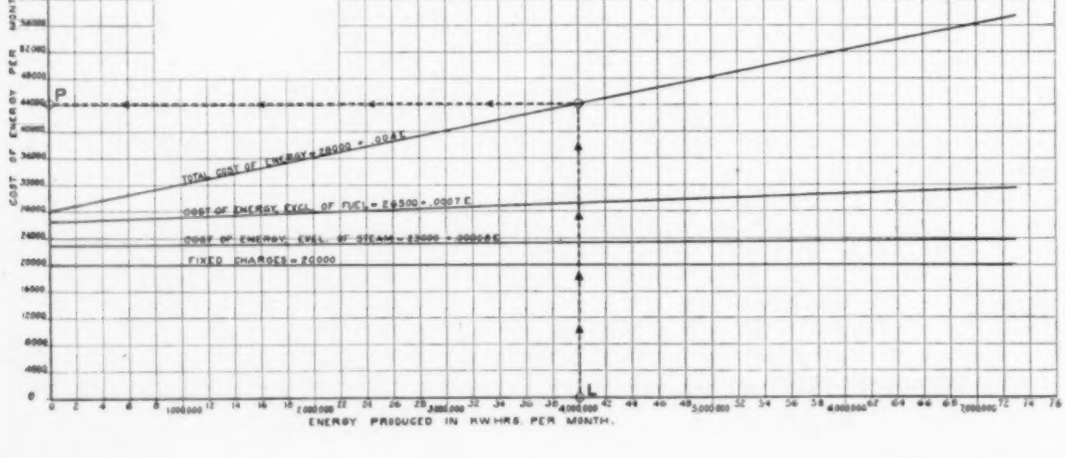

COST OF ENERGY PER MONTH.
P
TOTAL COST OF ENERGY = 20000 + .004E
COST OF ENERGY EXCL. OF FUEL = 20500 + .0007E
COST OF ENERGY EXCL. OF STEAM = 20000 + .000005E
FIXED CHARGES = 20000
L
ENERGY PRODUCED IN KW.HRS. PER MONTH.

Figure 18—Chart shows cost of operating isolated 15,000-kw coal-fired generating station. Boiler efficiency is 75 per cent and coal cost is $3.50 per gross ton. Data is based on 1929 figures. Compare with Figure 15.

The extra investment in a dual purpose plant chargeable to power generation will be at least 30 per cent of the cost of the boiler house. The turbine generators and electrical equipment usually run 50 per cent of the total investment in such a plant. From this it can be seen that at least 65 per cent of plant investment is chargeable to power. The amount of operating cost chargeable to power generation depends upon the efficiency which can be obtained and maintained in the dual operation. The efficiency depends upon being able to maintain over the life of the operation the heat balance and load factor for which the plant is designed.

Here again the fixed charges that management is willing to accept comes to the fore. The rate of return, the federal tax situation and the rate of depreciation due to possible shift of load conditions should be properly taken into consideration.

Perhaps in plants that have both by-product fuels and process steam needs, the best solution is to use the by-product fuel to manufacture the steam in a simple, low cost heating plant.

It is obvious from Mr. Skinkle's paper that it is no longer profitable for industrial concerns to invest money in power generating facilities. Even if by-product fuel is available or process steam is needed, the impact of federal taxes and the need for adequate return on moneys invested makes it increasingly difficult to justify an investment in power generating equipment.

W. B. Skinkle: The following closing remarks show some interesting results that have been attained as a result of rate studies of this general character. I gave a paper of almost identical character before this ESWP about twenty-two years ago. The change in the relative cost of purchased power as compared with a small customer-owned power house is startling. For this reason the figures corresponding to Figures 15 and 16 are reproduced herewith from the twenty-two year old paper. See Figures 17 and 18. When I saw the difference, I was so startled that I refused to believe Figure 15 was an accurate reflection of a 1951 small coal-fired power station cost. I took the pains to check it with several sources, one of whom gave me the opinion that Figure 15 was too conservative. In the old Figure, (See Figure 17) corresponding to Figure 16, three different utility rates were plotted representing the cost of purchased power. These are called Schedule A, B and C, and for the most part, are just slightly below the cost of a company-owned power station.

Now for some results that have been obtained as a result of power rate analyses. The first and simplest thing which I have found is that in plants having one or more motor generator sets in operation, have the power factor meter connected to the motor generator bus. This meter is always kept pointing to 100 per cent power factor and the operator is usually willing to tell you that he watches that meter carefully and always keeps it at unity. In one case in my experience, the works had approximately 4,000 kw demand at 70 per cent lagging power factor, making a 5740 kva of billing demand, or an addition of 1740 kva because of bad power factor. It was only necessary to disconnect this meter from the motor generator bus and spend a few dollars for additional wire to connect it with the bus in the incoming utility substation. The fields of the motor generator set were then "jacked up" and resulted in a unity power factor for the plant with a resulting saving in purchased power costs of slightly over $1,800.-00 a month.

Figure 19 represents small portions of the demand charts for six months out of a typical year where mills operating on purchased power were allowed to "go as you please." The various months are marked A, B, C, D, E, and F.

A careful estimate of power needs of the mill determined that 2400 kw was sufficient power to run the mill and a heavy line marked "controlled demand" at the 2400 kw line is shown on the charts. Take for example line "A." It was not necessary to be on the job to see the general superintendent demanding of various department heads to "get that order out and into this month's business." Note the response to that order as shown by the demand chart covering the last day of the month. The increase in production can be measured by the length and number of the lines above the "controlled demand" line. What did not show was that in the attempt to push out a little added production, $2,220.00 was added to the month's power bill.

Line "B" shows a group of five peaks all together when $2,430.00 was added.

Line "C" shows a group which added $3,105.00, and

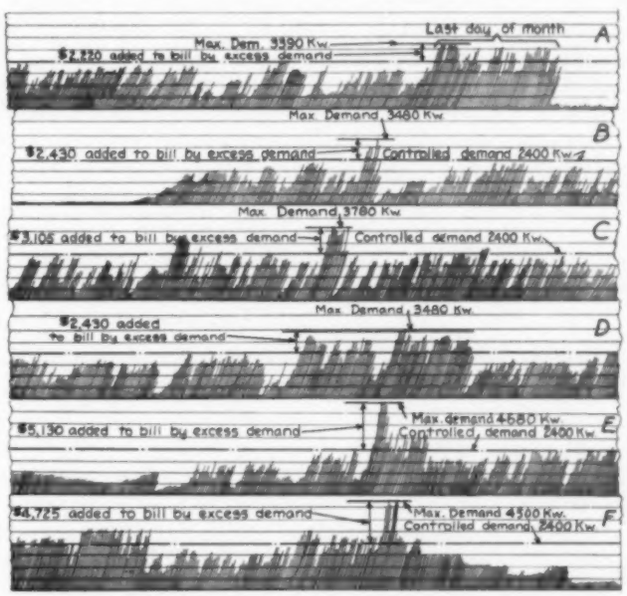
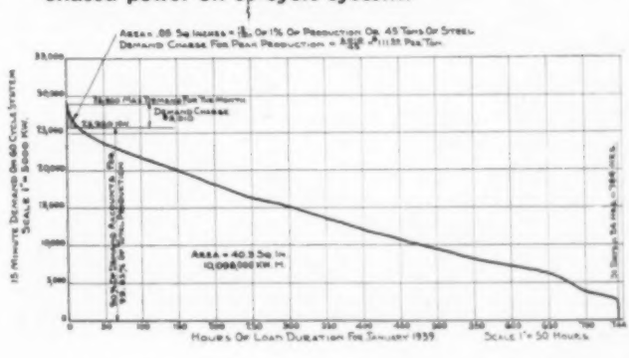


Figure 19 — Chart shows typical mill demand curves when mill is allowed to operate as it pleases.

Figure 20 — Chart shows load duration curve for purchased power on 60-cycle system.



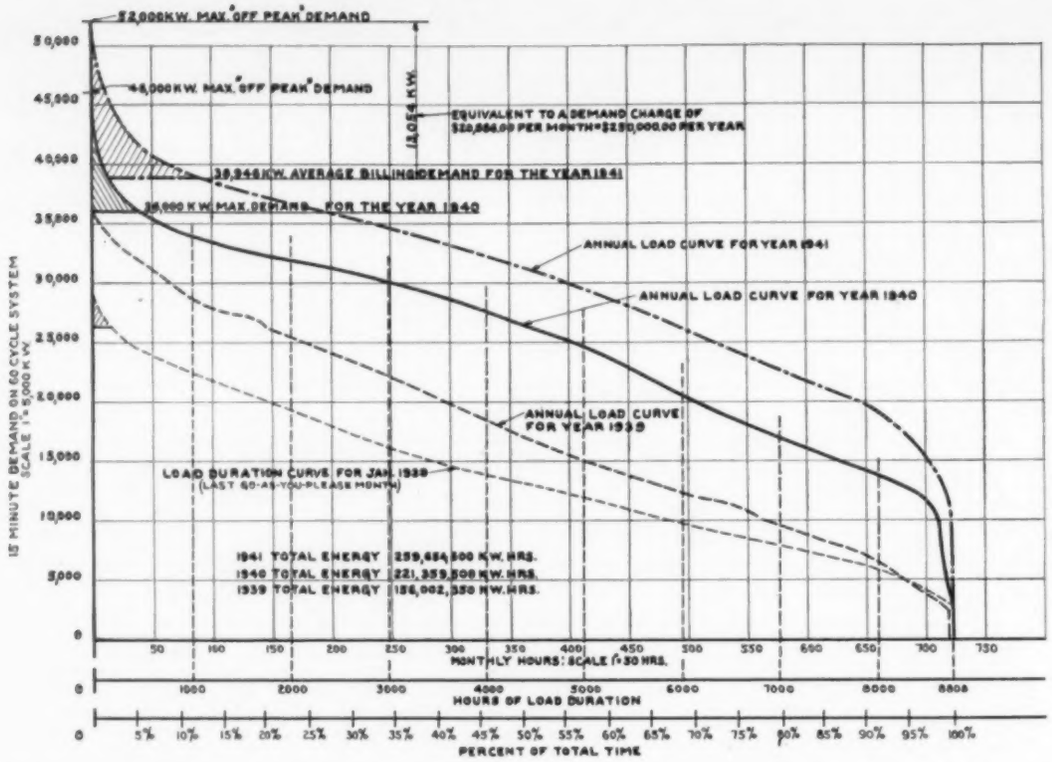

52,000 KW. MAX. OFF PEAK DEMAND
48,000 KW. MAX. OFF PEAK DEMAND
4,000 KW.
EQUIVALENT TO A DEMAND CHARGE OF $10,000.00 PER MONTH = $250,000.00 PER YEAR
38,944 KW. AVERAGE BILLING DEMAND FOR THE YEAR 1941
38,000 KW. MAX. DEMAND FOR THE YEAR 1940
ANNUAL LOAD CURVE FOR YEAR 1941
ANNUAL LOAD CURVE FOR YEAR 1940
ANNUAL LOAD CURVE FOR YEAR 1939
LOAD DURATION CURVE FOR JAN. 1939 (LAST GO-AS-YOU-PLEASE MONTH)
1941 TOTAL ENERGY 259,654,300 KW. HRS.
1940 TOTAL ENERGY 221,359,500 KW. HRS.
1939 TOTAL ENERGY 136,002,350 KW. HRS.
15 MINUTE DEMAND ON 60 CYCLE SYSTEM SCALE 1" = 5,000 K.W.
MONTHLY HOURS: SCALE 1" = 30 HRS.
HOURS OF LOAD DURATION
PERCENT OF TOTAL TIME

Figure 21—Chart shows several load duration curves for purchased power on 60-cycle system. With controlled conditions, energy cost was reduced as shown by the 1941 curve.

in line "D" the mill made a record and all the men got cigars. Also, the company had $2,430.00 added to that month's power bill. In both lines "E" and "F," a minor interruption to the operation of a steam turbine that supplied part of the power to the plant caused all the load to be put into the purchased power circuits for a little over an hour. In one case, $5,130.00 was added to the power bill, and in the other case $4,725.00 was added to the power bill. The author at one time calculated the added power used during the peak of line "E." The cost calculated to $1.19 per kwhr.

In the same plant during the depression year of 1933, everybody was cost conscious and willing to listen to anybody who said he could save a nickle. A demand limiter was installed on the incoming purchased power circuit, and an adjustable time switch which controlled a red light was installed at the heating furnaces of the largest mill. When a bloom was pushed out of the furnace, the red light was turned on and remained illuminated for the required number of seconds. The heater was instructed that as long as the light was "on" no bloom was to be drawn from the furnace. There were about eight or nine steps to the rolling process and almost every order put a "bottle neck" at some one of these steps. The motor tender, who had nothing to do while the mill was running, was instructed to keep the time switch set at a rate that would just keep the bottle neck full.

In May, the last "go as you please" month, the mill used 1890 kw of demand, rolled 1830 gross tons of steel and made 15,000 lb of scrap. Later under controlled conditions the same mill used only 900 kw of demand, rolled 3360 gross tons of steel and made only 16,000 lb of scrap. The maximum number of interruptions to production was ten in seventy-two hours.

At another job of this kind, a Lorenz curve or load duration curve was plotted. These curves are made by placing the largest load at the left of the diagram and arranging loads in their decreasing order until the smallest load is at the extreme right. In Figure 20, the vertical ordinate represents kilowatts and the horizontal ordinate represents hours so that the area under the curve represents kilowatt hours. Notice the high peak at the upper left of the figure. The height of the shaded area represents 10 per cent of the demand. The area that is shaded represents only 15/100 of 1 per cent of the production, or 45 tons of steel. The demand charge represented by the height of the shaded area cost $5,010.00, or at the rate of $111.50 a ton for that top peak production. Inasmuch as the steel was selling for about $60.00 a ton, that peak production was rather expensive.

A complete demand control system was worked out for this mill and installed at a cost of about $20,000.00. Figure 21 shows the results. The year 1941 was the first full year under controlled conditions. As a result of a combination of the load control and the enlarged load (which cannot be separated mathematically) the cost per kilowatt hour was reduced 2.74 mills and 260,000,000 kwhr were purchased, making a total power cost reduction for the year of $713,000.00. The operation of the load dispatching cost about $1,000.00 a month.

The shaded area at the upper left of the curve represents power purchased during off peak hours. This plant listed its products in the order of power requirements for rolling. The scheduling department placed the tough rolling products into off peak hours, or for week-ends.

This was a great help, particularly when new markets for tough rolling products were being developed. Had it been necessary to pay the extra $250,000.00 demand charge and had that charge been placed against the new products, it is doubtful if the new products would have been developed.

POLLUTION CONTROL PROGRAM FOR OHIO

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Engineer in Charge
Water Pollution Control Unit
Division of Sanitary Engineering
Ohio Department of Health
Columbus, Ohio

. . . . because of recent legislation, this paper is of particular interest . . . .

▲ IN Ohio, authority of water pollution abatement and control is vested in the Ohio Department of Health by specific statutes. Development of pertinent legislation no doubt has been influenced by the intimate relation of water quality to public health. Hence recognition of the department as the regulatory agency in matters pertaining to water quality has not been merely happenstance.

STATE LEGISLATIVE AUTHORITY PRIOR TO 1949

In the interim 1893 to 1949, laws adopted by the Ohio Legislature required that the Department of Health approve plans of proposed sewerage, sewage treatment and disposal, and, industrial wastes treatment and disposal works (Sections 1240 and 1240-1 G.C.); gave the department supervision of the operation of all sewage and industrial wastes treatment and disposal facilities (Section 1240-2 G.C.); and imposed obligations on the department to study the waterways of the state for determining water uses, causes of pollution and practicability of preventing pollution and to recommend corrective measures for the prevention of damage to public health and welfare (Section 1240-3 G.C.). Further, the law, generally referred to as the Bense Act (Section 1249 to 1261 G.C.), placed authority in the department for ordering stream pollution correction if findings so warranted after receipt of a formal complaint from one or more specified agencies. However, in accordance with the provisions of this act, it was necessary that the findings show nuisances damaging to public health or comfort or pollution of a public water supply. Amendments to the original act, decisions of the Supreme Court upholding the constitutionality of the law, and test cases establishing the validity of suits in mandamus, commenced in the Supreme Court by the Director of Health, to enforce orders under the act, gave some impetus to stream pollution correction. Notably among such cases were the State vs Williams, Delphos (1929), and the State vs the City of Columbus (1934).

Supported by the legislative authority as cited, the Department of Health endeavored to utilize its personnel to the best interests of all, in a promotional and educational program to encourage acceptance of responsibilities by agencies contributing pollution. It is definitely felt that this approach was rewarded by much good will and by the cooperation of many agencies both municipal and industrial. Accomplishments were evidenced by these facts: first, that, as of 1949, 238 municipalities serving approximately 3,500,000 people of the state were being served by sewage treatment facilities; second, that, also as of this date, approximately 155 industries had provided correction of industrial wastes disposal problems; and, third, that an indeterminate number of industries had taken steps of preparation or modification of liquid wastes for satisfactory disposal into the facilities of municipal sewage works. Notwithstanding these accomplishments, a serious weakness in the water pollution regulatory structure was that a stream or waterway had to be found completely despoiled to the detriment of public

Figure 1 — A mobile laboratory unit consisting of a station-wagon and trailer is used for stream pollution surveys.

health and comfort, before concrete enforcement measures could be taken against an indifferent or recalcitrant offending agency. Further, the director of health had been given no authority to initiate action of prevention even in the most flagrant cases. The need for measures to prevent pollution was definitely realized.

DEVELOPMENTS INCIDENT TO RECENT LEGISLATION

Interstate legislation in the form of the Ohio River Valley Water Sanitation Compact and federal legislation in the form of Public Law 845, the former having been formally consummated on June 30, 1948, coincident with the signing of the latter by the President, strongly emphasized public opinion with respect to energetic prosecution of a program for restoration of waterways to conditions of cleanliness. In neither of the above was the right or responsibility of the state usurped in any way. Therefore it was fitting and in accordance with the pledge of Ohio as a signatory state of the Ohio River Valley Water Sanitation Compact, that the 98th (1949-1950) Ohio General Assembly should consider the adoption of new legislation supplementing the then existing statutory authority pertinent to water pollution abatement and control. Section 1240-4 of the General Code of Ohio, effective August 25, 1949, is designed to make unlawful the discharge of sewage or industrial wastes into waters of the state or waters forming boundaries thereof which jeopardize the public health or welfare of citizens of the state, unless works or means satisfactory to the director of health shall have been installed within a time reasonable for treating or otherwise disposing of sewage or industrial wastes.

Conforming with interstate and federal legislation, the new law seeks pollution prevention. Although definitely stressing the premise that protection of public health is the most significant reason for water pollution control, it at least suggests a broader definition of pollution. It is intended to make possible the logical approach of restoring and protecting our waterways for water uses consistent with the economic and social welfare of our citizens. The fact that approximately 75 per cent of the population of Ohio is served by public water supplies obtained from surface sources, without question emphasizes the public health priority.

From the effective date of the law, one year of educational program was permitted for municipalities and industrial establishments to accept their responsibilities toward compliance. On the premise of correcting "worst things first" and further with the conviction that municipalities generally should lead the way, the director of health in September 1950 cited 20 cities, all of which were without sewage treatment facilities and none of which had given satisfactory evidence of compliance, to the attorney general for action in accordance with the provisions of the law. This citation is presently under study in the attorney general's office. An opinion as to the feasibility of this law, its workability, and as to a procedure of prosecution in accordance with it is awaited. Advanced information is not particularly favorable.

Figure 2 — The station-wagon is used also for collection of samples.

INTERSTATE LEGISLATION

The Ohio River Valley Water Sanitation Compact is an agreement of the states of the basin to uniformly approach and prosecute a reasonable program of water pollution abatement and control. Article I of the compact states in part, "Each of the signatory states * * * agrees to enact any necessary legislation to enable each such state to place and maintain the waters of said basin in a satisfactory sanitary condition * * *." Ohio therefore has a responsibility of adopting legislation for full compliance with the terms of the compact as ratified.

One of the provisions of the compact, Article VI, stipulates that all sewage discharged into Ohio River or its tributaries must be treated; the minimum degree of treatment as specified is that ordinarily accomplished by efficient sedimentation and is defined as the removal of settleable solids and 45 per cent of the suspended solids. A greater degree of treatment may be required by the commission. Another provision in Article VI stipulates that all industrial wastes likewise tributary to the Ohio River system must be treated; the degree of treatment is not specified technically but is described "* * * to such degree as may be determined to be necessary by the commission * * *." In this connection it is interesting to note the wording of the introductory paragraph of Article VI which reads as follows: "It is recognized by the signatory states that no single standard for the treatment of sewage or industrial wastes is applicable in all parts of the district due to such variable factors as size, flow, location, character, self-purification, and usage of waters within the district. The guiding principle of this compact shall be that pollution by sewage or industrial wastes originating within a signatory state shall not injuriously affect the various uses of the interstate waters as hereinbefore defined."

The commission is authorized to adopt rules and regulations for administering the provisions of this article. In accordance with this authority, the commission has enunciated the policy that responsibility for bringing about the objectives of water pollution control of the compact rests primarily with those state

agencies within each state already charged by law with the administering of water pollution control, and that the activities of the commission are intended to supplement those of the state agencies. In Ohio, for instance, the Ohio Department of Health is the regulatory agency. Water pollution problems of interstate significance are the ones which it is expected will receive the attention of the commission, but in cooperation with the states involved. By specific provision of the compact (Article IX), action by the commission toward enforcement must receive the assent of the majority of the commissioners of each of not less than two-thirds of the signatory states and must further receive the assent of the majority of the commissioners of the state in which the action is to be taken.

Promotion of uniform policies among states, coordination of efforts, and the correlation and dissemination of information pertinent to the over-all program are most valuable activities of the commission technical staff. From industry standpoint, the effort that is now being made to inaugurate and promote "industry action groups" for defining waste problems, for conducting industrial wastes research problems, and for developing feasible methods of wastes elimination and/or modification holds much promise for satisfactory solutions within the realm of economy. The states in turn will benefit materially by information that can be dispensed by the action committees through the commission technical staff.

FEDERAL LEGISLATION

Public Law No. 845 bears the title, "To provide for water pollution control activities in the Public Health Service of the Federal Security Agency and in the Federal Works Agency and for other purposes."

In section one of this act, the policy of Congress was declared to be (a) "to recognize, preserve, and protect the primary responsibilities and rights of the states in controlling water pollution," (b) "to support and aid technical research to devise and perfect methods of treatment of industrial wastes which are not susceptible to known effective methods of treatment," (c) "to provide federal technical services to state and interstate agencies and to industries," and (d) "to extend financial aid to state and interstate agencies and to municipalities, in the formulation and execution of their stream pollution abatement programs." Responsibilities of the program were placed with the surgeon general of the public health service and with the federal works administrator.

Some of the provisions of this act are as follows: (1) A report is to be prepared by the surgeon general setting forth a comprehensive program of pollution abatement needs. (2) The surgeon general is instructed to encourage water pollution control activities by the states through uniform state laws, interstate compacts, cooperative activities, support and aid in technical research on industrial waste treatment. (3) State water pollution control agencies are eligible for grants-in-aid to assist in carrying out control activities. (4) An eleven man advisory board recommends policies and programs; board comprised of five exofficio federal representatives and six outside of federal employ to be appointed by the President, one of whom represents affected industry. (5) Under certain conditions, action for abatement of pollution may be taken by the surgeon general: (a) if interstate waters are involved, (b) if health or welfare is affected of people in downstream or adjacent states, and (c) if the state water pollution control agency requests or consents to the action.

From a federal level also, the assistance of industry has been solicited. Suggested by the U.S.P.H.S. and sponsored by the Water Pollution Advisory Board (the eleven member board), a National Technical Task Committee on Industrial Wastes, has been created to effect an Industry-Federal Government approach to the control of water pollution caused by industrial wastes. This committee has announced that its purpose is "to effect an improvement in the quality of water resources in the nation," and that its objective is "to perform technical tasks pertaining to industrial wastes in cooperation with the P.H.S. and all others concerned with improving water quality. This committee is now functioning and the reports of its activities give promise of material accomplishments. This activity further emphasizes the trend from state to federal levels for united, cooperative effort.

PROPOSED STATE LEGISLATION

It is recognized that legislation is primarily an expression of public opinion. However, sound, reasonable legislation is essential as a structure on which to build a sound and reasonable program of water pollution abatement and control within the confines of our state and in conformance with the pledge of our state with neighboring states.

By reason of shortcomings of existing statutes including some uncertainty relative to the adequacy of the 1949 legislation (Section 1240-4), a "Water Pollution Control Act" S.B. No. 62 has been introduced by Senator Deddens, Cincinnati, for consideration of the

Figure 3 — The trailer has complete facilities for analyzing the samples.

99th General Assembly. It is not within the province of the writer to discuss this bill in detail except to point out certain features which should be of interest to engineers of industry and to urge that engineers carefully weigh the merits of legislation of this nature. The author of the proposed bill has been guided basically by a model "Water Pollution Control Act" which with the assistance of the U.S.P.H.S. has been prepared for and approved by the Council of State Governments. The proposed legislation is basically uniform with those of other compact states. The bill would create within the Ohio Department of Health, a Water Pollution Control Board on which both municipal and industrial interests would be represented, thereby rightfully giving these interests voice in an important and essential program. It permits the abatement and control of pollution consistent with water usage.

ORGANIZATION FOR WATER POLLUTION CONTROL

Within the Ohio Department of Health, the Sanitary Engineering Division, under the direction of the chief engineer, has as an important technical phase of its activity the prosecution of the abatement and control of water pollution. This division enjoys the close cooperation of the Division of Laboratories in all matters pertaining to the analytical characteristics of pollutants and polluted waters.

In anticipation of the increased tempo of water pollution control, there was organized in 1949 within the Sanitary Engineering Division, a Water Pollution Control Unit. With trained experienced sanitary engineers of the division as a nucleus, this unit was expanded within budgetary limits. The grant-in-aid pursuant to the provisions of Public Law 845 was instrumental in making expansion possible. Nine engineers of this unit give primary attention to matters pertaining to sewage and industrial wastes disposal problems, to stream studies and to all features pertaining to pollution control. However, by a closely knit organization under the chief engineer, the services of engineers in other units of the division are definitely interlocked to strengthen the overall program. Furthermore, district engineers of five established districts are available for cooperative efforts in the respective areas.

The Division of Laboratories maintains central facilities adjacent to Ohio State University in Columbus. This division, staffed with qualified technical personnel for chemical, bacteriological and biological examinations, is prepared to handle all analyses pertinent to problems of water quality. The staff is capable of coping with all problems both from the standpoint of routine procedure and from the standpoint of research. As a matter of fact, much work has been done with reference to standardization and development of analytical procedures.

A mobile laboratory unit, procured and placed in operation during 1949, provides facilities for "on the spot field studies" of sewage and industrial wastes characteristics and of streams and other watercourses. The unit comprises a 25-ft trailer (Figure 1). A station wagon which also serves for collection of samples and as a crew carrier is used as a tow car (Figure 2). Contained in the laboratory unit are laboratory equipment and supplies (Figure 3 and Figure 4) sufficient to make all usually required chemical, bacteriological and biological examinations. The items of equipment range from delicate balances to large units for incubation and refrigeration. Standard water and electrical connections have been provided so as to obtain respective services from a selected premise. Otherwise the unit is self-contained.

Planning of field work, the execution of field studies, and the correlation of data is the duty of the Water Pollution Control Unit. However, general supervision of the laboratory tests and examinations made in the field is had by the chief chemist, Division of Laboratories. Also personnel of the central laboratory are available for special problems.

This organization for water pollution abatement and control within the Ohio Department of Health is comprised of personnel basically trained and equipped for an established program. Further, this organization can be readily expanded to meet exigencies of any future program.

Figure 4 — This illustration shows the other end of the trailer from that shown in Figure 3.

OBJECTIVES OF WATER POLLUTION STUDIES

The primary objective of the water pollution control program is the restoration and protection of waterways of the state to extents consistent with water uses. Therefore identical criteria for all streams cannot be accepted. The policy has been and is, first, to determine what, in the interests of the citizens in the area, should be the uses, and, second, to establish the stream water quality objectives or water quality standards consistent with the uses. Each stream and frequently sections thereof present entirely different problems.

The program involves complete studies for evaluation of pollution and its effects by river basin. To illustrate, Figure 5 graphically shows the sources and extent of organic pollution found by a complete 1949 survey of the Miami River. Figure 6 indicates the number of stream sampling points for determining the effects.

Hence, the following steps in a study can be appreciated.

1. By careful sampling and analysis and by measurements of sewage and waste flows, individual and aggregate pollution loads are evaluated. This includes organic and inorganic wastes.

2. Stream sampling, performed simultaneously with the above, determines effects of pollution under conditions of stream flows occurring at the time of survey.

3. Careful hydrological studies are made of the streams. All stream flows of record are examined. Frequently curves are developed and critical drought flows are selected. It is not reasonable nor economically feasible to fix pollution abatement requirements on the lowest flow of record, or on a condition the probable occurrence of which will be once in, say, 25 years. The condition usually selected is a seven consecutive day drought flow, that which will likely occur once in 5 to 7 years. Mother Nature does not always perform as might be expected, but what has occurred over past years can be used scientifically as a guide to future probabilities.

4. An evaluation of factors, other than volume of stream flow, which influence the self-purification capacity of the stream is given consideration.

5. Finally, the allowable pollution loads are determined, which during critical flow periods will meet the water quality objectives fixed in accordance with water usage. The allowable pollution loads in turn fix the degrees to which sewage and wastes must be modified, reduced or eliminated.

ACTIVITIES AND ACCOMPLISHMENTS

Accomplishments of water pollution correction under the so-called original program, prior to 1949, as noted above, were definitely of real consequence, though restricted by legislative authority, limited personnel and economic conditions during World War II. Anticipating the inception of a "new era" of water pollution control, the sanitary engineering division immediately after the war placed major emphasis on stream pollution and pollution fact finding. In the years 1946 through 1948, in addition to routine duties, two major river drainage basins, the Mahoning and the Cuyahoga, were covered from the standpoint of location of pollution sources, and from the standpoint of tabulation of data determinable from observations and inspections. Although the fact finding surveys need to be supplemented by more thorough analytical data, the problems in these basins were reasonably well defined, permitting reasonable consideration of corrections required.

Activities since 1949, the new era, are particularly worthy of comment:

1. A complete study of the Miami River drainage basin has been completed and full report made; degrees of pollution reduction have been established, and each agency, municipal and industrial, in the entire area has been notified specifically of its problems and of the correction necessary.

2. A complete field survey of the Maumee River drainage basin for the determination of pollution loads and of the effects of these on the main river and its tributaries has been completed; the final studies and preparation of report are under way by which specific problems will be defined and on the basis of which each agency will be apprised of corrections necessary.

3. Fifteen special studies involving sewage treatment plant performance where industrial wastes were prime influencing factors, and involving the definition and evaluation of specific industrial wastes have been made. For instance, four of these were in connection with phenol wastes disposal for elimination of taste and odor problems; one was for defining a paper mill waste; one was for evaluating a combined problem of oil refinery, beet sugar and rubber reclaiming wastes; another was for measuring the effect of acid iron wastes on a municipal sewage treatment process; and others were for determining the effects of packing house and milk wastes on municipal sewage treatment plants.

4. Personnel of the engineering and laboratory divisions and the mobile laboratory facilities were used in cooperation with industry and the technical staff of the Ohio River Valley Water Sanitation Commission in the control of experimentation for the destruction of phenols by chlorine, chlorine dioxide and ozone. An interim report on laboratory and pilot plant studies, performed at the by-product coke plant of Armco, New Miami, has been made by personnel of the commission staff. Technically, phenols can be destroyed by proper application of each agent noted. However, no effort will be made at this time to discuss relative merits.

5. A Lake Erie pollution survey was undertaken in cooperation with the Ohio Department of Natural Resources. In this, the Ohio Department of Health assumed full responsibility for supervising the collection of samples, for supervising the bacterial and sanitary analyses, and for the interpretation of results of sanitary data collected. A progress report showing sanitary conditions of lakeshore beaches and furnishing guidance for future studies and for feasible corrective measures has been prepared and will be included as a very significant part of an over-all progress report.

6. Cooperating with other signatory states bordering on the Ohio River and generally supervised by the technical staff of the Ohio River Valley Water Sanitation Commission, personnel of the water pollution control unit and of the central laboratory participated in a joint survey during 1950 for further evaluating the effects of existing pollution on the Ohio River and for furnishing guidance toward the proper corrective program.

7. Another project of 1950 in which the water pollution control unit participated in cooperation with the U.S.G.S. laboratory, the Corps of Army Engineers and the Ohio River Valley Water Sanitation Commission, the latter correlating and supervising all efforts, was a brine survey of the Muskingum River. The data collected will serve as an evaluation of the brine disposal problem, the elimination and control of which presents a task requiring the best scientific efforts forthcoming from all interested agencies.

8. The department has entered upon a joint project with the Engineering Experiment Station for the construction and operation of a pilot sewage treatment

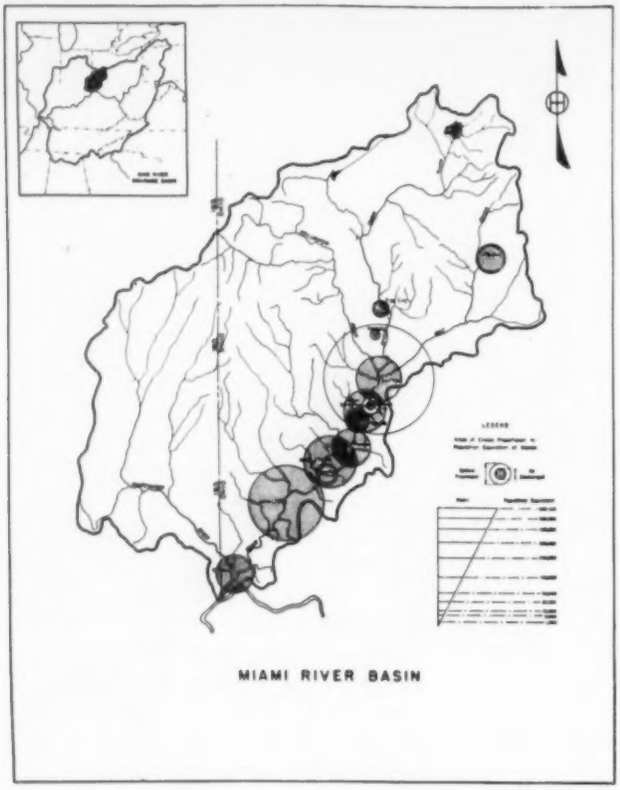

Figure 5 — Sources and extent of organic pollution in the Miami River are shown in this sketch which was developed by the Stream Pollution Survey unit.

Figure 6 — Sketch shows location of sampling points for Miami River basin.

plant to be located on the grounds of the Ohio State University. These facilities will be used in research studies for the determination of effects and tolerances of critical industrial wastes on the normal processes of sewage treatment. A portion of the necessary construction monies has been appropriated by the Ohio Legislature. The operation of the proposed facilities is being made possible by a "Special Industrial Wastes Study" federal grant incident to the provisions of Public Law 845.

A measure of accomplishments taken from annual reports of the chief engineer are the estimated values of proposed sewerage and industrial wastes improvements in Ohio during 1949 and 1950 as represented by detail plans approved. These were $23,057,868 and $18,786,-145, respectively. The decrease for 1950 no doubt reflects the uncertainty arising from present world affairs, accompanied by gradual tightening of supplies of basic materials. It is significant, however, that even by adjusting these values to a recognized 1929 construction cost index, they are well above the average value for the past 22 years.

Most of the improvements placed under construction or completed during 1950 are represented by plans approved during the previous year or two. Progress during 1950 in sewerage and sewage treatment and in industrial wastes treatment may be summarized as follows: Important sewerage improvements were undertaken in 29 different municipalities. Important industrial wastes treatment improvements were undertaken at 16 industrial establishments. Included in the foregoing were 6 new sewage treatment plants. The combined estimated cost of the above improvements completed or placed under construction was approximately $16,000,000.

PROPOSED FUTURE PROGRAM

The future program of water pollution abatement and control requires the completion of the evaluation of pollution by watershed. Simultaneously with this will be the task of conducting frequent inventories of information obtained by initial basin studies. The policy has been established that the waterways should be employed up to their capacities for absorbing pollution so long as the cleanliness preserved is consistent with rightful usage. Consequently municipal and industrial growths, changes and expansions of industrial processes, and greater demands on the potential uses of waters in a locality may very probably necessitate adjustments of pollution reduction requirements or, even, adjustments in water quality objectives or standards.

In a sense, the approach to the water pollution control program in our state involves stream classification although, at present, there has been no effort to label streams as Class A, B, C, etc. Consideration of water uses and the prerequisite of fixing tentative water quality objectives, "something to shoot for," serves as a stepping stone to ultimate "stream classification." A future program anticipates the reasonable classification of waterways from which they shall not deteriorate, but from which conditions of betterment may be sought by reason of continued efforts toward sewage

and industrial wastes modification and/or elimination.

The proposed program emphasizes cooperative effort—the state water pollution control agency with interstate and federal agencies, with municipal governments and with industry. Engineers in the industrial fields are best acquainted with wastes resulting from manufacturing processes and are best prepared to undertake research studies for determining methods of wastes elimination or modification. Consequently the regulatory agency will endeavor to promote industrial waste studies, correlate efforts and interpret accomplishments from a stream sanitation standpoint.

The proposed program is designed to seek and promote closer cooperation between municipalities and industry. Many industrial waste disposal problems can best be solved jointly with municipal sewage in municipal works. Appreciation of industrial problems by municipal representatives is considered essential, and equally important is appreciation of municipal problems by industrial representatives. At state level this is being encouraged through our Ohio Sewage and Industrial Wastes Treatment Conferences, and at federal level by the Federation of Sewage and Industrial Wastes Associations, meetings of both of these organizations being held annually.

Specifically during 1951, the major undertakings which are planned by the Water Pollution Control Unit, in addition to activities incident to the general program and to the consummation of features of the program that have been initiated thus far, comprise a complete pollution survey of the Muskingum River Basin, a continuation of the Lake Erie Pollution Survey, and, active participation in research of the effects of metallic wastes on conventional and accepted processes of the treatment of sanitary sewage.

SUMMARY

Water is one of our most valuable natural resources. Without water we would not exist. Safe water for drinking and domestic supplies (public health) has first significance. Clean water of sufficient quantity is absolutely necessary for industrial use, an economic significance. Clean waters are essential for recreation, for the support of fish life, and for live stock watering, all having an intimate bearing on the welfare of our citizens. Reasonably clean water is required for economic transportation to serve many of our factories. In fact, clean water is life-giving. Consequently the correction of pollution as a means of conservation of this natural resource, so essential to a continued high standard of civilization, should not be considered a burden.

Pollution today is a product of our great industrial era. The problem has grown in leaps and bounds for the past 100 years as greater masses of people have been concentrated in our major cities to satisfy manpower demands of expanding industrial activities. It is believed that public opinion, generally, is aroused to meet the challenge of the continued despoiling of our waterways. As an expression of public opinion, sound but reasonable legislation is required as a structure upon which to build a well conceived and equitable program of water pollution abatement and control. It would be unfortunate if minority groups are permitted to unduly delay water pollution correction because of selfish motives.

The Ohio Department of Health is basically staffed and equipped for supervising a program as outlined. Basic knowledge and appreciation of the problems involved have been gained over the years. Accomplishments as measured by existing and proposed corrections are by no means insignificant. There is a challenge, however, to keep apace with the developments of our rapidly moving age. Although there is some danger of retardation of progress by reason of the presently confused world affairs, the activities thus far initiated point to a long range program as well as to immediately essential corrective measures. It is definitely felt that the essence of the success of the program lies in a helpful, cooperative, reasonable, though firm, approach to difficult water pollution problems. Much hope may be had for the restoration of waterways to conditions of cleanliness consistent with indicated proper water usage, provided the united efforts of our state, our people and our industry are experienced.

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NEW DEVELOPMENTS IN SCRAP HANDLING FOR THE OPEN HEARTH

By L. R. RISSLER
Section Engineer, Elevator Division
Westinghouse Electric Corp.
Jersey City, N. J.

. . . . elevators are used at Armco in an unusual arrangement to move materials from the ground to the charging floor . . . . marked reductions in charging time have resulted from the adoption of this plan . . . .

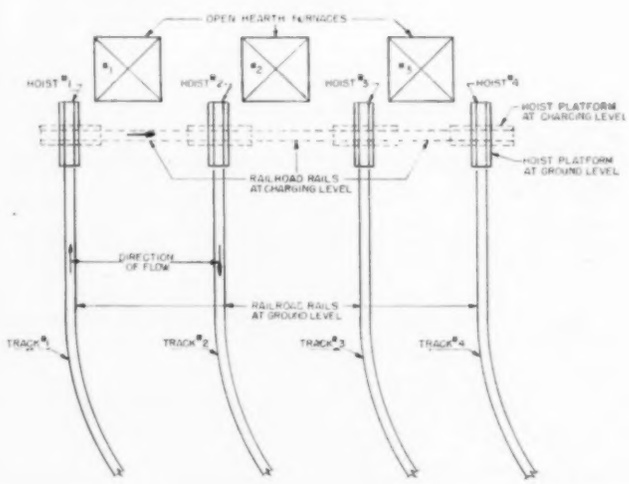
▲ THE layout and the equipment installed for handling materials in the new open hearth building of Armco Steel Corp. at Middletown, Ohio, have many novel characteristics, all of which should increase the efficiency of the plant. The basic modification over present methods is in the use of hoists for lifting the charging buggies from the ground level to the charging level.

Figure 1 shows the location of the hoists with respect to the furnaces. The cold charging materials are brought into the plant at the ground floor level on special railroad flat cars which carry four pans of charging material each. The flow of the charging cars is laid out in such a way that there is a regular circuit which eliminates the interference of the empty cars and loaded cars, especially when more than one furnace is being charged at the same time, that is so common in present practices. Assume that furnace No. 1 is being charged. The loaded cars are lined up on track No. 1 at the ground level, in front of hoist No. 1. The first car is mechanically pushed onto the hoist platform and positioned on the platform rails by a cager.

The cager is a device that engages lugs on the side of the car. The engaging dog is moved by power from a given position in front of the hoist platform to a point that places the car centrally on the hoist platform. The cager is operated by push buttons from the same station used for operating the hoist. It is interlocked with the hoist so that interference between the cager and the hoist cannot occur. Another device moves the succeeding car into position for the cager to load the hoist. During this period the hoist raises the preceding car to the charging level. Thus, a train of cars on any of the tracks at the ground level are loaded individually onto the hoist by a sequence of semi-automatic operations.

The hoist platform movement is initiated by pushing an "up" button. In its vertical movement to the charging level, the hoist platform is automatically rotated through 90 degrees which then places the charging cars so that they may be pushed from the scrap hoist platform by the charging machine to any position in front of furnace No. 1. The charging machine then charges the furnace in the conventional manner and the empty car and pans are pushed onto hoist No. 2, which lowers the empty car to the ground level where it is pushed off onto track No. 2 by No. 2 cager. While the charging proceeds, hoist No. 1 has returned for another load and has placed this second car into position at the charging level by the time the first car has been emptied and placed on hoist No. 2. This procedure continues until furnace No. 1 has been fully charged. Thus, it can be seen that each car from the train on track No. 1 is moved up to position in front of hoist No. 1, pushed onto the platform, elevated to the charging level,

Figure 1 — The hoists are located in front of and in between the open hearth furnaces.



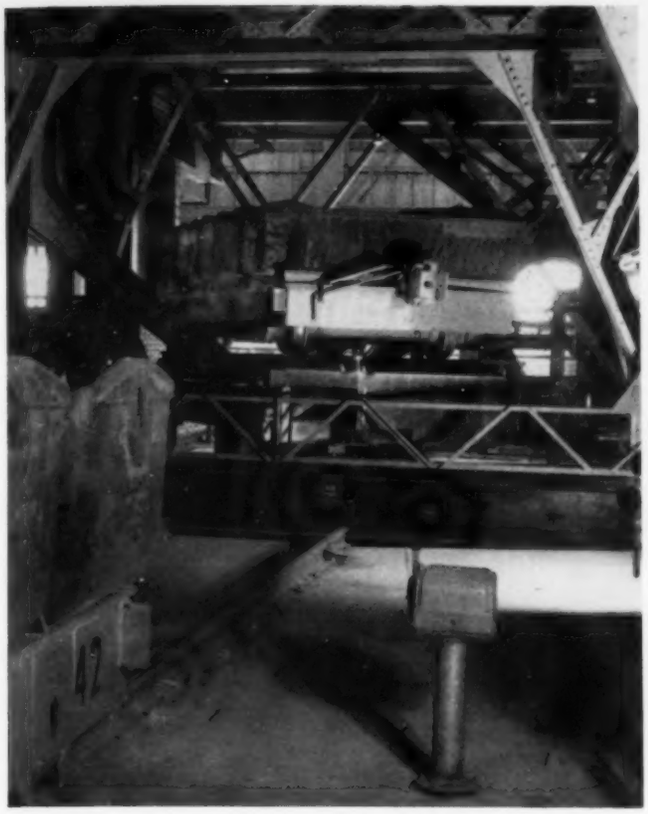


Figure 2 — Illustration shows scrap buggy with pans being elevated from the ground level.

moved to a charging position in front of the No. 1 furnace, the charging material placed in the furnace, the empty car is moved onto hoist No. 2, lowered to the ground level and pushed onto track No. 2. This forms a train of empty cars on track No. 2 to be pulled away for another load. The circuit which the charging cars have, provides a continuous flow of charging materials to the furnace with no lost motion or interference of the empty cars with loaded cars. Furnace No. 3 can also be charged at the same time as furnace No. 1 using hoists No. 3 and No. 4 with no interference as the hoists are completely independent of each other.

Figure 2 shows the position of the platform after just above the ground level.

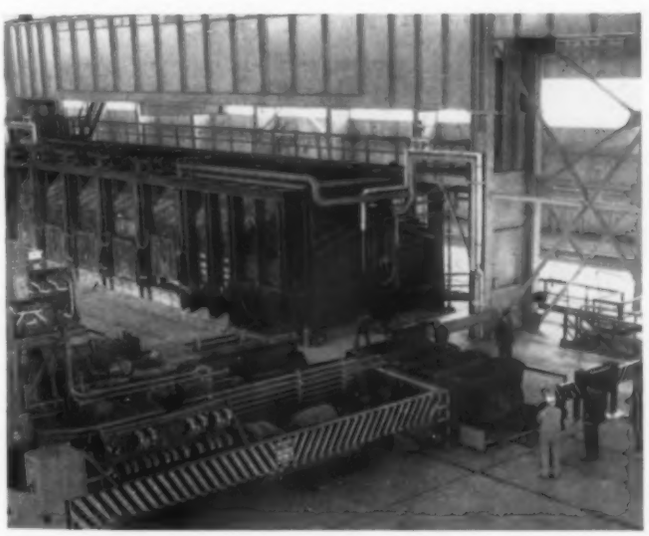
Each hoist is capable of raising 45,000 lb from the ground level to the charging level in 25 seconds. The round trip time is 120 seconds of which 32 seconds is used for loading, 25 seconds up, 31 seconds to unload, 32 seconds to return to the ground level, which completes the cycle. The distance from the ground level to the charging level is 20 ft-6 in. All the hoists are identical and completely independent of each other, which provides the utmost in flexibility. Each hoist is also capable of hoisting 83,400 lb at an increased time cycle. The platform is 19 ft -4 in. long and 10 ft-1 in. wide.

Figure 4 shows schematically the hoisting arrangement. The platform is shown at the ground level with a scrap car on the platform rails. It is raised by a 22 in. diameter direct acting hydraulic ram operating in a cylinder that is sunk in the ground. The platform is rigidly connected to the top of the ram, the ram and platform being free to rotate. The top of the ram directly beneath the platform is held in position by a ram guide. The ram guide is approximately 22 ft long and each end is guided by rollers, which run in vertical guide rails. The ram passes through a bushing in the ram guide, which permits the platform and ram to rotate with respect to the ram guide. The ram guide moves vertically with the platform. With this arrangement, the ram is held rigidly in its vertical position and can withstand the eccentric loading which occurs on the platform.

To conserve energy and power requirements, an accumulator tank is used to supply hydraulic power to the ram (See Figure 5). The liquid medium is a water and oil mixture. The operating pressure is a maximum of 350 psi gage. A centrifugal pump operated by an electric motor supplies liquid under pressure to the pressure tank. The pump runs continuously during the charging cycle as the characteristic of the pump maintains the proper pressure, automatically. Make-up air for the pressure tank is supplied by an electrically driven air compressor and is controlled manually. When the delivery of the centrifugal pump is low, cooling of the pump is provided by by-passing a small amount of water around the pump through a cooler and back into the storage tank. This is a closed system so that the liquid is recirculated and requires additional liquid to provide for leakage only.

The position of the piston shown is in the shut off position when the hoist platform is at either the charging level or ground level. The next position of the cycle with the platform at the charging level will be to move the piston up, thus opening the cylinder to the storage tank through the porting. To admit liquid under pressure from the pressure tank to the cylinder, the piston is moved down, thus opening the cylinder to the pressure tank through the valve porting. For this installation, the valve piston uncovers the valve porting by means of an electric motor, pinion and rack. The motor is de-energized by the proper limit switches after the valve piston has reached its full stroke. The portings are closed mechanically at the terminals by a parallel linkage device being contacted by a member of the ram

Figure 3 — Charging machine is shown returning empty buggies to the hydraulic lift.



guide. Push buttons at the charging level, ground level, at the control valve, and on the charging machine initiate the control valve motor. This permits the hoist to be operated from any of these stations with some restriction by interlocking for safety reasons. For example, the hoist cannot be operated unless the locks are in a retracted position, or the hoist cannot be operated from the ground level when the platform is at the charging level. Thus, interlocks are provided to insure that the hoist can be operated only under safe conditions.

The platform is held tight against the charging level by permitting the hydraulic pressure to remain in the cylinder while at the charging level. Vee shaped stops, (see Figure 6), in combination with this pressure assures accurate positioning of the rails on the platform with the rails at the charging level. When the platform is at the ground level, pressure to the cylinder is removed and the weight of the platform and load rests on similar Vee stops which again assures accurate positioning of the platform rails with respect to the ground level rails.

The platform is rotated through 90 degrees automatically during its ascent or descent by the use of a helical shaped cam placed at one of the corners of the platform. Rollers are mounted to the platform and engage this cam. Thus, as the platform moves in its vertical travel, the cam forces the platform to rotate by means of the cam rollers on the platform. The cam is rigidly mounted to the building structure. At the charging level and the ground floor level, cam rollers are loose on the cam, which permits Vee blocks to take control of the platform and accurately position the platform rails with respect to the rails at the landings.

When the hoist is shut down, it is parked at the charging level and locked into position by pneumatically operated locks. The locks wedge the platform between the Vee stops and the bevelled nosing on the lock, which makes the platform a solid and rigid part of the charging level and can be used as part of the charging floor. In case of a shut down of a hoist, the scrap cars may be rolled across the parked platform, which reduces the possibility of a complete shut down.

The control valve is a balanced type and is used to admit liquid under pressure to the ram from the pressure tank or directs the liquid from the cylinder to the storage tank depending upon the requirements. This special type valve has been developed for heavy duty installations of this nature. It is particularly rugged, free of maintenance, and its performance is ideally suited for the control of liquid under pressure. Figure 7 shows that the valve consists of a shell with a bronze bushing insert in which the piston slides. An annular space is provided in the shell which is connected to the cylinder through a pipe. The annular space is within the orifice position of the bushing. The orifices are covered by the control piston. The other piston is provided to assure a hydraulically balanced condition within the valve. The high pressure liquid is constrained between the two pistons which are fastened rigidly to the piston rod. A by-pass and dashpot pipe is provided to permit liquid to pass from one end of the valve to the other as the piston is moved. It is also used as a dashpot to dampen any transients in the control operating mechanism as well as to control the speed at which the valve is operated. The rate of admission into or out of the cylinder is controlled by the design of the control orifices in the valve and the rate at which they are covered or uncovered. This permits smooth acceleration and deceleration of the hoist platform which reduces impact forces to a minimum, thus reducing wear and danger of structural failure, and leads to reliable operation.

An emergency stop feature is provided for this hoist to permit any operating station to stop the platform in

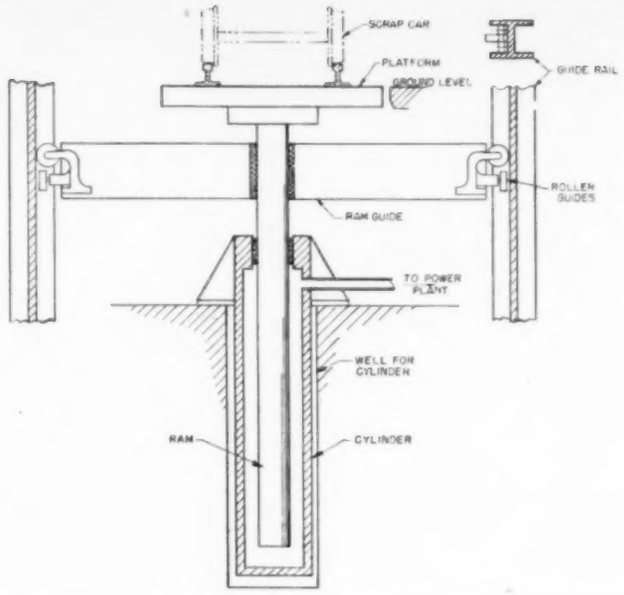
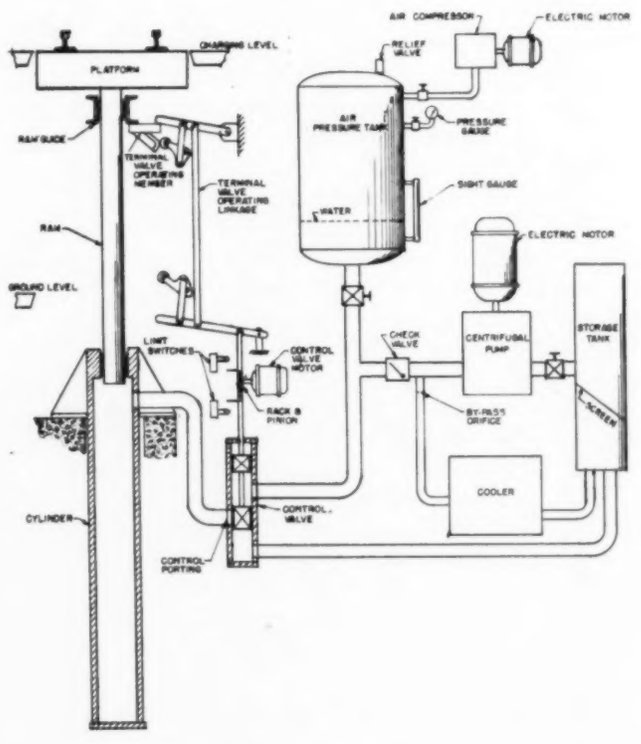


Figure 4 — The hoisting arrangements consist primarily of a hydraulic ram in a cylinder.

Figure 5 — The power plant scheme for actuating the ram is shown in this schematic.



any position in its ascent or descent. This mechanism is a set of scissor type jaws, the face of one end being lined with brake lining and engages the vertical member of the valve operating mechanism. Spring actuated scissors pinch the vertical member. It is released by an electromagnet. The emergency stop mechanism is mounted on the ram guide. A control cable is hung from this mechanism to supply electrical power for its release. When the control circuit is energized, the electromagnet releases the scissor grip on the vertical valve operating member, and the control valve and hoist may be operated in a normal manner. If it becomes necessary to stop the hoist platform in its travel, a stop button at any of the control stations may be pushed. This de-energizes the electromagnet and permits the spring to operate the scissor which clamps the valve operating member. Since the emergency stop mechanism moves with the ram guide, it will move the valve piston in the proper direction to close the valve porting and stop the platform. This operation is smooth and with the proper valve porting the hoist platform is brought to rest quickly and smoothly.

Figure 8 shows, schematically, the control used for the hoist. There are four stations from which the hoist may be controlled. One control station is located on the charging machine and only permits stopping or lowering of the hoist if the platform is less than three feet from the charging level. Another station is located at the cager operating station and controls the stopping, raising or lowering of the hoist if the platform is more than three feet from the charging level. The third station is placed at the charging level and controls the stopping or raising of the hoist if the platform is less than three feet from the charging level. The other station is placed near the control valve which permits stopping, raising or lowering of the hoist with no zoning restrictions and is used primarily for maintenance. DL and UD are contacts in a switch placed in the hatch way. A cam on the ram guide establishes the zone for restricting the use of the various stations. Contacts PL1 and PL2 are switches on each pneumatic lock which indicates to the control whether the locks are in the proper position for the hoist to be operated. The contact M prevents the hoist from being operated unless the pump is running. VLL and VRL are contacts in the limit switches at the control valve and de-energize the direction switches L and R when the valve has been fully opened by the valve motor, which in turn removes power from the valve motor. The operating buttons are held closed manually until the limit switch contacts VLL or VRL have dropped the direction relays. This time is of the order of one second. After any emergency stop, it is necessary to manually reset the controlling contactors before the hoist may be operated. All of the emergency stop operations de-energizes NV_1, which removes power from the emergency stop coil and permits the spring on the emergency stop device to grip the vertical rod on the valve control mechanism and close the valve by the vertical movement of the hoist ram guide. The flashers RFR and LFR signal at the level to which the platform is moving through contacts VRL and VLL on the valve limit switch. This warns the operators when the hoist is moving in their direction. The pump motor may be started or stopped at the cager operating station or at the controller. The air compressor motor can be started only from its controller. An indication at the cager station that the pump is running is accomplished by a light wired around M on the starter for the pump motor.

To prevent dirt from fouling the apparatus in the hatchway, heavy guards are placed over the guide rollers and the control valve mechanism is housed in a dust-tight metal cabinet.

Figure 9 shows the characteristics of the power plant during the hoisting cycle of the hoist that is being used to raise the scrap or charging material from the ground level to the charging level. This particular hoist is the one which determines the hoisting cycle because the hoist that lowers the car and empty pans travels from

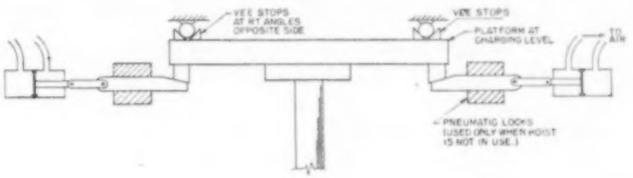
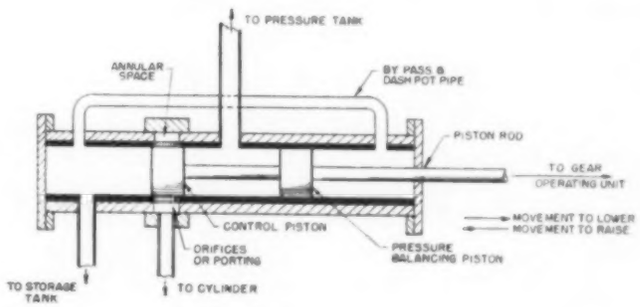

VEE STOPS AT RT. ANGLES OPPOSITE SIDE
VEE STOPS
PLATFORM AT CHARGING LEVEL
TO AIR
PNEUMATIC LOCKS (USED ONLY WHEN HOIST IS NOT IN USE.)

Figure 6 — Vee stops position the elevator at the charging level.

Figure 7 — Sketch illustrates operation of control valve.



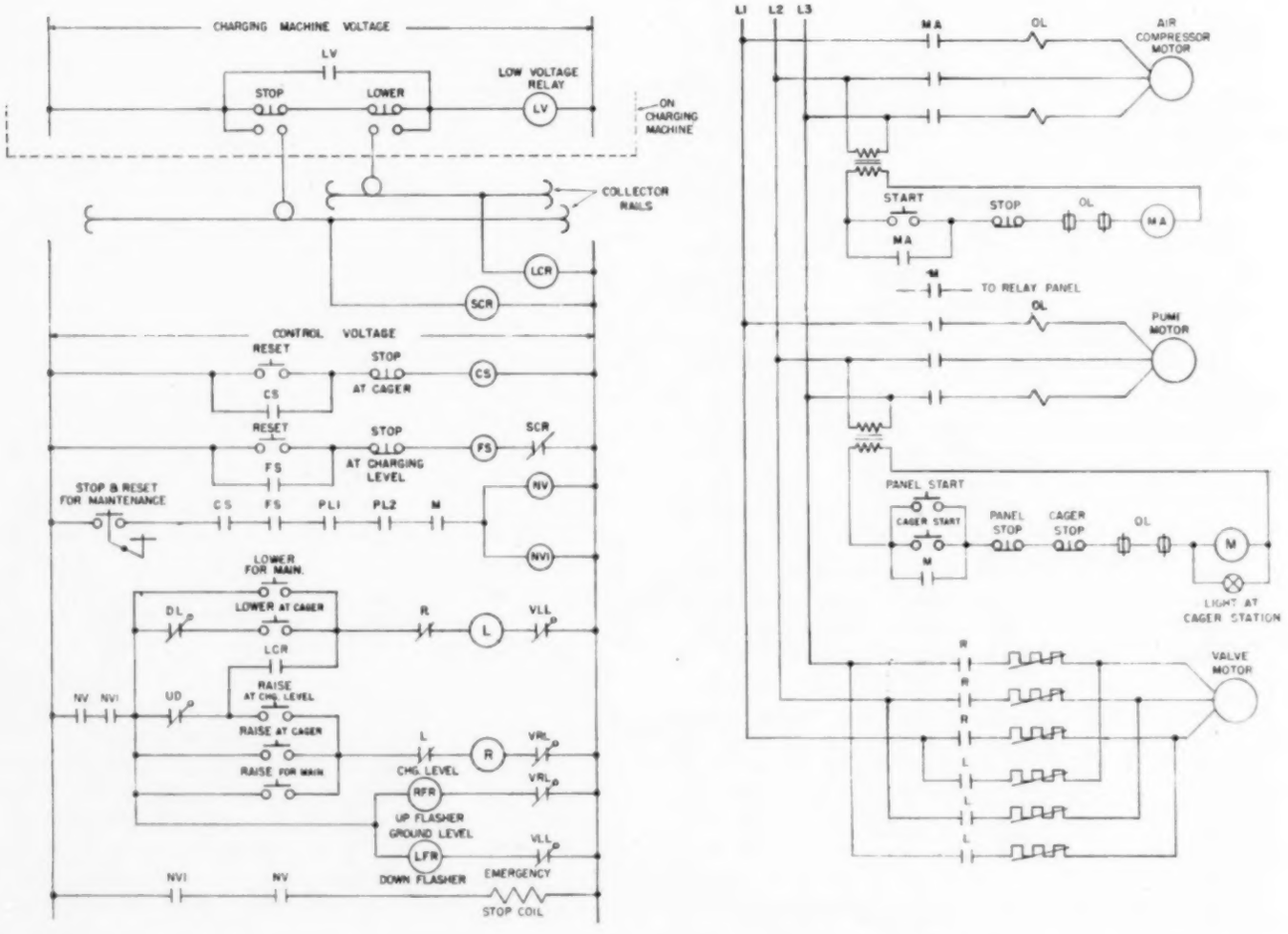
the charging level to the ground level and from the ground level to the charging level in a shorter time than the other hoist. The various characteristics are plotted against time, where zero time is taken as the time at which the "up" button is pressed to raise the 45,000-lb load. The travel curve shows the hoist accelerates to full speed in approximately one second and the slope of the curve indicates that the hoist travels at a uniform speed of 48 fpm. When it is within approximately 9 in. from the charging level of 20 ft-6 in. elevation, it is decelerated to a low velocity before engaging the Vee stops and brought to rest. Thirty-one seconds is used for moving the car off the hoist platform by the charging machine after which the empty hoist platform is lowered to the ground level at a speed of 39 fpm or a total lowering time of 32 seconds. Thirty-two seconds is taken for the cager to move the next loaded car onto the hoist platform after which the cycle is repeated. At zero time, the tank pressure is 350 psi gage. As the hoist platform moves up, the air pressure in the pressure tank drops to 300 psi in the first 25 seconds, because the valve permits a larger volume of water to enter the cylinder than the pump is capable of delivering. Since

the total tank volume is constant and the water volume is reduced, the air volume increases which results in a reduced pressure. In the next 95 seconds, the control valve does not permit water to be bled from the pressure tank. During this period, the pump replaces the water to the pressure tank from the storage tank, thus restoring tank pressure back to 350 psi; ready for water to be used for the next cycle. The curve showing the air volume in the pressure tank indicates that with increased air volume, the tank pressure is reduced. The cylinder pressure required at zero time is somewhat greater than the pressure during the rest of the travel because additional pressure is required to accelerate the hoist platform, load, water, ram and ram guide. At the 25 second point, less pressure is required because the above masses are decelerated. From 25 seconds to 56 seconds the full tank pressure is used in order to hold the platform tight to the charging level Vee stops. From 56 seconds to 88 seconds, a reduced cylinder pressure is required as zero load is lowered. From 88 seconds to 120 seconds, no cylinder pressure is required, after which the requirements repeat. At zero time, the pump discharge to the pressure tank is zero as the pump output pressure balances the 350 psi pressure in the pressure tank. As the tank pressure drops, the pressure-delivery characteristics of the pump are such that full pump delivery is attained in a short time. As can be seen, the tank pressure determines the delivery of the pump. The brake horsepower supplied by the pump motor is proportional to the pump discharge as can be seen from the curve. Eighty horsepower maximum is required for approximately 10 seconds during the cycle. To raise this load directly requires 156 horsepower. Thus, the accumulator tank reduces appreciably the size of the power machinery and reduces the operating power consumption.

The pressure difference between the tank pressure and the required cylinder pressure is absorbed by the pipe losses and the control valve orifices. It can be seen that this system adequately raises larger loads at a reduced speed, which indicates that the system will handle any loading which the operating crew places in the pans since scrap varies appreciably in volume weight ratio. This leads to reliability.

Figure 10 shows the time for the hoist to raise or lower the various loads. Since there is no speed regulating device with this equipment, the orifice characteristics in the control valve are of a definite value for the up and a definite value for the down position. If the control valve is adjusted to attain a particular time for a given load up, and a particular time for a given load down, the other loads will have a speed, which permits

Figure 8 — Electrical control scheme for operating the charging elevator.



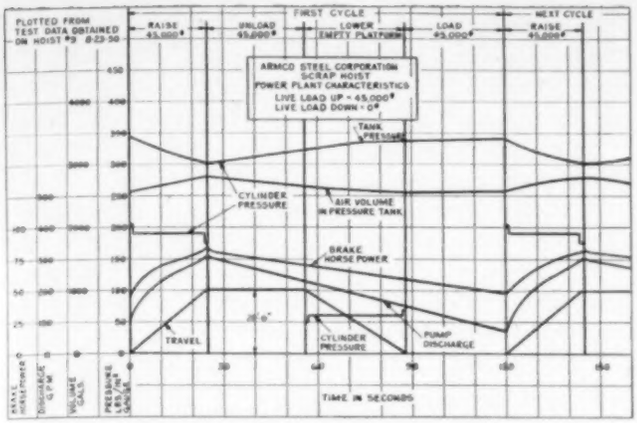


Figure 9 — The characteristics of the hoisting cycle are given in this draft.

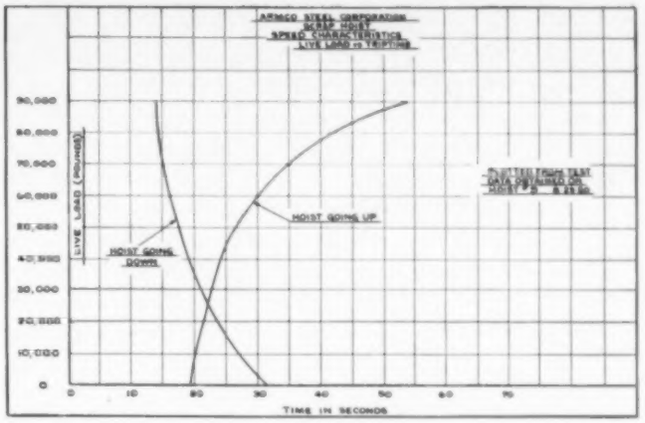


Figure 10 — Speed characteristics of the hoist are given by this draft.

hydraulic pressure balance in the circuit. With the orifices set to give the curves, as shown in this figure, it can be seen that the hoist will raise an 80,000-lb load from the ground level to the charging level in 42 seconds or it will raise a 60,000-lb load in 30 seconds. It will lower no-load in 32 seconds and lower 30,000 lb in 21 seconds.

These values are based on the fact that the difference in pressure in the pressure tank and that required by the cylinder is absorbed in passing through the control valve orifices, and this drop in pressure is proportional to the square of the velocity of the liquid passing through the control valve orifices or the speed of the hoist platform.

All reasonable features have been provided on this equipment to facilitate repairs and maintenance, and to reduce shut-down periods for repairs to a minimum.

DISCUSSION

PRESENTED BY

W. J. REILLY, Manager, Steel Mill, Ford Motor Co., Steel Division, River Rouge, Mich.

L. R. RISSLER, Section Engineer, Elevator Division, Westinghouse Electric Corp., Jersey City, N. J.

PAUL E. LINDBERG, JR., Melting Superintendent, McLouth Steel Corp., Trenton, Mich.

C. W. CONN, General Superintendent Steel Production, Ford Motor Co., Dearborn, Mich.

L. R. MILBURN, Consulting Electrical Engineer, Whitmore Lake, Mich.

H. F. LESSO, Open Hearth Control & Material Metallurgist, Great Lakes Steel Corp., Ecorse, Detroit, Mich.

M. V. PROBST, Sales Engineer, Babcock & Wilcox Co., Detroit, Mich.

PHIL E. HAGLUND, Superintendent, Raw Materials and Semi-finished, Ford Motor Co., Dearborn, Mich.

H. W. CLARK, Metallurgical Engineer, Ford Motor Co., River Rouge Plant, Dearborn, Mich.

J. L. BUELL, JR., District Manager, Reliance Electric & Engineering Co., Detroit, Mich.

W. J. Reilly: It is an old open hearth experience where you are running only one furnace, to get the heats bunched up. Is it possible to charge No. 1 and No. 2 furnaces at one time, or No. 2 and No. 3 without a great deal of interference?

L. R. Rissler: The maximum efficiency is not attained from this system when adjacent furnaces are charged simultaneously. Suppose furnaces No. 1 and No. 2 are to be charged. Then the loaded charging pans would be hoisted to the charging level on hoist No. 1 for furnace No. 1 and the loaded charging pans for furnace No. 2 would be hoisted by hoist No. 3. The empty charging pans would for both furnace No. 1 and No. 2 be lowered to the ground level by hoist No. 2. Since hoist No. 2 has a power plant large enough to hoist loaded pans and lower an empty platform, the time cycle is appreciably less for lowering empty flat cars and returning to the charging level empty. With the existing installation, hoist No. 2 will almost handle the empty cars from both hoist No. 1 and hoist No. 2. If this is a problem, the hoist handling the empty flat cars could be arranged to lower the empty cars from two hoists as fast as necessary.

W. J. Reilly: If your hoist was down on No. 1 for some mechanical breakdown, how would you charge that furnace?

L. R. Rissler: If No. 1 hoist is down for repairs and furnace No. 1 is to be charged, it is necessary to use hoist No. 2 and No. 3. Hoist No. 3 would be used to raise the loaded car and hoist No. 2 to lower the empty cars. The circuit would then be: The charging machine would move the loaded car at the charging level from hoist No. 3 across hoist No. 2 to furnace No. 1. The scrap would be charged into furnace No. 1 and the empty flat car is moved to hoist No. 2 and lowered to the ground level. While this takes place, hoist No. 3 has brought another load to the charging level. Since the round trip time of hoist No. 2 is less for handling empty cars than for loaded cars it is back in position for the succeeding charge to be pushed across it when needed. The major amount of time lost under this con-

dition is the increased distance the charging machine must drag the loaded cars.

Paul Lindberg: How does the stock house connect with the melt shop, or, how are the buggies returned? Are the buggies returned in a round-house rotation? Can you get from No. 1 track to No. 3 track? Are you ever in danger of bunching the buggies?

L. R. Rissler: The buggies could be returned to the stock house on separate tracks from the loaded ones going into the melt house, which would keep them from interfering. In addition several parallel tracks could be arranged in the stock house for loading and weighing. They can then be pulled onto the track leading to the melt house and then switched to the track leading to the appropriate hoist. The emptys can be returned on separate trackage.

C. W. Conn: The stock house, I presume, is going to be at right angles to the open hearth mill shop?

L. R. Rissler: The stock house does not necessarily have to be located at right angles to the open hearth mill shop. The tracks from the stock house leading into the open hearth mill shop must approach the hoists at an angle such that the tracks will not interfere with the hoists. If the tracks are brought into the hoists at the ground floor at say 30 degrees, the platform would only have to be rotated 30 degrees instead of 90 degrees.

C. W. Conn: On the way up, the ram rotates, and positions the buggy in line with the charge track upstairs?

L. R. Rissler: Yes.

C. W. Conn: Is there any kind of safety device going to be placed around this opening?

L. R. Rissler: There are automatic stanchions which are raised to form a protection around the hole, when the hole is open, and which are automatically lowered when the hoist comes up.

L. R. Milburn: What is the advantage of this system over our old method of bringing the buggies up the ramp and pulling them onto the open hearth charging floor?

L. R. Rissler: Some of the advantages of this system over the existing methods are as follows:

1. A means is provided to remove the empty flat cars after charging. This prevents bunching of the emptys and the problem of removing them.
2. Adjacent furnaces may be charged with little interference of the emptys as they are removed from the charging level individually as soon as their load has been charged.
3. The charging level is relatively clean and free of flat cars.
4. Long ramps are avoided.
5. A loaded charging car is always available for the charging machine. Thus, the charging time depends upon how fast it can move the flat cars and charge. It is possible that two charging machines can be used for charging one furnace, using say three hoists.
6. The units are independent, which permits a maximum in flexibility.

L. R. Milburn: Do you need the long tracks on the charging floor?

L. R. Rissler: There are tracks which connect the platforms at the charging level in front of the furnaces.

W. J. Reilly: One advantage is that you do not have any empty cars in front of the other furnaces. You drop your cars away from the furnace you are charging, and you do not have any interference in front of the others.

L. R. Rissler: You can charge No. 1 and No. 3 at the same time and have no interference.

L. R. Milburn: Do you have the same speed of operation that you have in the conventional method?

L. R. Rissler: There is an appreciable reduction in time required to charge a furnace with this method compared to the present method.

H. F. Lesso: Basically, what economies would be involved in this new method?

L. R. Rissler: The basic economy for this system is that a furnace can be charged faster than the present method because there is a constant flow of material to the furnace with no interference from the empty cars. This, of course, means more charges per unit of time per furnace.

Paul Lindberg: How large are these furnaces?

L. R. Rissler: The furnaces are 300 tons each.

H. F. Lesso: How would this particular charging method function with a battery of twelve furnaces where you have multiple sizes, multiple furnace capacities, and likewise multiple furnace dimensions? I have reference to length particularly. Supposing you had a battery of twelve furnaces, and there were three of them that differed in length with the remaining nine furnaces. How would you adopt such a charging operation?

L. R. Rissler: The hoists would be placed between and in front of the three furnaces as shown in Figure 1. The hoists for the nine would be placed between these furnaces. If the capacities varied for the furnaces, the capacity and speed of the hoists would be made to match the furnaces. If the dimensions between furnaces varied, the charging machine drags the flat cars a variable distance. If the furnaces are too far apart, it may work out to be more economical to have a pair of hoists for each furnace. The platforms and distance between hoists are fixed after installation. They can be installed to satisfy most any distance from one to the other and the platform can be most any size.

M. V. Probst: Do each of the hoists have individual tanks and pumps and other necessary equipment?

L. R. Rissler: Yes, they are completely independent of each other.

M. V. Probst: In that way each one could be operated at a different speed then?

L. R. Rissler: Yes, you can do anything you want with them. You can go ten times as fast if you want to. There is no reasonable limitation.

H. F. Lesso: What would be the floor space required?

L. R. Rissler: For the particular installation we are talking about, some of the physical sizes are as follows:

1. Platform size—19 ft 4 in. long x 10 ft 1 in. wide. This would be the space required at the charging level.
2. Pressure tank—14 ft long x 6½ ft diam.
3. Storage tank—10 ft long x 4 ft diam.
4. Pump and motor—7 ft x 2 ft 6 in.

The valve and its control is located under the platform so no extra space is necessary for it. The space

required would mean more if volume were considered because the tanks may be hung from the ceiling and the pump and electrical control placed under it. This system can be condensed into a rather small space considering the power requirements of the system.

Phil E. Haglund: I would like to ask the speaker, what is the width of this platform? Is it the width of the five furnace doors? Is there only one lifting ram for each furnace?

L. R. Rissler: If you refer to Figure 1, you will see that the hoists are placed to the front and each side of the furnace. The charge pans are loaded on charging cars that are pulled off the hoist platform and moved in front of the furnace for charging. The platform is made only large enough to easily accommodate the charging cars. One lifting ram is used for each hoist.

Phil E. Haglund: Do you have a track in front of the furnace?

L. R. Rissler: Yes, a track is placed in front of the furnace.

H. W. Clark: What provisions are made to keep dirt and loose buggy scrap from getting down into the conveyor and plugging the system?

L. R. Rissler: As the charging cars approach the hoist, they pass between two cams that force the charging pans into a central position on the charging cars. This prevents the pans from hanging over the edge of the cars with the danger of striking obstructions in its vertical motion during hoisting. The movement (both rotary and linear) of the hoist platform is so smooth that there is very little danger of scrap falling off the car. There is little danger of scrap falling off the hoist platform because of the precautions taken to make the various movements of the hoist platform smooth. This does not appear to be a serious problem.

J. L. Buell, Jr.: How are the cars moving across in front of the furnaces? If they are pushed by a charging machine, how do you avoid interference?

L. R. Rissler: Interference is avoided because each empty car is lowered to the ground floor after charging so the empty charging cars do not pile up on the charging floor.

J. L. Buell, Jr.: How does the charging machine get the cars off the hoist?

L. R. Rissler: The charging machine hooks on to a pan and drags the car over in front of the furnace and charges in the conventional manner. It then moves over to a hoist. The platform is in position, and lowers the empty car to the ground floor. While doing that, the other hoist has another load for the charging machine. Thus a regular circuit is established. The hoist raises the load, rotates, charge, across to the other hoist, rotates, unloads and goes up for another empty.

L. R. Milburn: The whole advantage in that system is the lack of congestion on the charging floor.

L. R. Rissler: Yes, that is the major advantage.

FINSIDER MODERNIZES PLANTS WITH ERP AID

▲ THE Finsider Co. is part of the government owned I.R.I.—Instituto Ricostruzione Industriale—the Italian RFC, a financial giant born out of the 1931 depression and mushroomed in the following years.

The Finsider (more accurately Finanziaria Siderurgica i.e. company designate to finance the iron and steel industry in Italy) controls now the largest Italian manufacturing companies of steel products in Italy responsible for the production of about 80 per cent of the total Italian pig iron output, 67 per cent of crude steel and 51 per cent of finished products.

The main operating companies controlled by Finsider are:

ILVA, Alti Forni e Acciaierie d'Italia.
DALMINE, S.p.A.
SIAC, Societa' Italiana Acciaierie Cornigliano.
TERNI, Societa' per l'Industria e l'Elettricita'.

Almost totally destroyed by war action and German depredation the plant of the Finsider group had a negligible production in 1946. A speedy reconstruction work has placed production on an annual level of better than one million tons of steel, but demand is still way ahead of capacity.

In spite of increased production, Italian steel capacity is far below normal standards of efficiency, is still below prewar and still operates on obsolete uneconomic processes. The Finsider has devised and approved a far reaching and large scale project of reconstruction designed to give Italy an adequate steel capacity. Adequate financing has therefore been made available both with lire funds and ECA dollars. It should be pointed out, however, that the ECA finances only the reorganization of the Integrated Plants owned by ILVA and by SIAC, since these plants represent the backbone of the Italian production of pig iron and crude steel.

The integrated plants located at Bagnoli (Naples) and Piombino are operated by ILVA, Alti Forni e Acciaierie d'Italia, while that located in Genoa-Cornigliano is operated by SIAC, Societa' Italiana Acciaierie Cornigliano.

The first two plants are already in operation and the program now calls for the installations of new heating and rolling facilities for a more economical production of steel billets, steel rods and wire rods.

The Cornigliano plant which was dismantled by the Germans during World War II is now being rebuilt with the equipment recovered from Germany and implemented with the installation of modern facilities for the production of pig iron and crude steel (two 750-ton blast furnaces, five 180-ton Martin furnaces.) This plant has been chosen as the proper location for the installation of the semi-continuous 80-in. hot strip mill, the only mill of this kind to be erected in Italy.

The Finsider project involves the expenditure in dollars and dollar equivalent of more than $110,000,000. Out of this, about $26,000,000 represent direct dollar financing granted so far by ECA for equipment to be purchased in the States. The balance represents expenditures to be made in Europe for equipment that can be produced there and for the preparation of sites and building construction.

Operations for the most important units of the Finsider project—rolling mills at Bagnoli and blast furnaces at Cornigliano—are scheduled for the end of this year.

TECHNICAL PROGRAM OF THE

American Iron and Steel Institute

. . . . in reviewing problems of iron and steel production, leading operators of the steel industry, at the fifty-ninth general meeting of the American Iron and Steel Institute held in New York City on May 23 and 24, presented a number of interesting papers . . . . special panels were held on Steelmaking, Sinter, Raw Materials, Plant Operation and How Industrial Relations Can Contribute Toward Maximum Productivity . . . . because of their value to the industry, some of the papers are abstracted here . . . .

"OXYGEN AS A MEANS OF INCREASING BESSEMER PRODUCTION"

By W. G. McDONOUGH, Superintendent
Open Hearth and Bessemer Department
National Tube Co.
McKeesport, Pa.

▲ AS a means of increasing bessemer production, it was decided in the fall of 1950 to experiment with oxygenated blast in one of the 28 net ton acid bessemer converters at National Tube Co.'s National works plant in McKeesport, Pa.

The main purpose was to melt as much additional scrap as possible in the bessemer converters over a two month period during which there was a shortage of hot metal. The experiments had to be limited to a single converter, since the plant oxygen supply was insufficient to operate two converters with oxygenated blast at the same time.

It might be said that the use of oxygen in one converter has been continued on a limited basis. Experience to date has shown that under normal operating conditions, in a charge of 60,000 lb, 4000 to 5000 lb of additional steel scrap can be melted by the use of 4000 to 6000 cu ft of 99.5 per cent pure oxygen per blow, with a reduction in blowing time of about one minute. To date more than 2900 oxygenated blows have been made, during which time about 6000 additional tons of scrap have been melted, using approximately 15,000,000 cu ft of oxygen. No particular difficulties have been encountered from the blower's point of view regarding flame characteristics and temperature reading. Converter bottoms and lining life have shown no adverse effects from the use of oxygen, with an indication of some improvement.

The conclusion is reached that about 26 per cent scrap is the optimum that can be used in a bessemer converter charge in practical operations. This percentage of total scrap charged will, of course, be governed by the analysis and temperature of the iron, and other operating factors. As the scrap charge is increased, the hot metal charge must be decreased to maintain normal heat weight, thus reducing the proportion of charge elements which produce heat. This reduced amount of

Figure 1 — Chart shows additional scrap charged per blow and additional scrap per 1000 cu ft oxygen as related to the volume of oxygen used per blow.

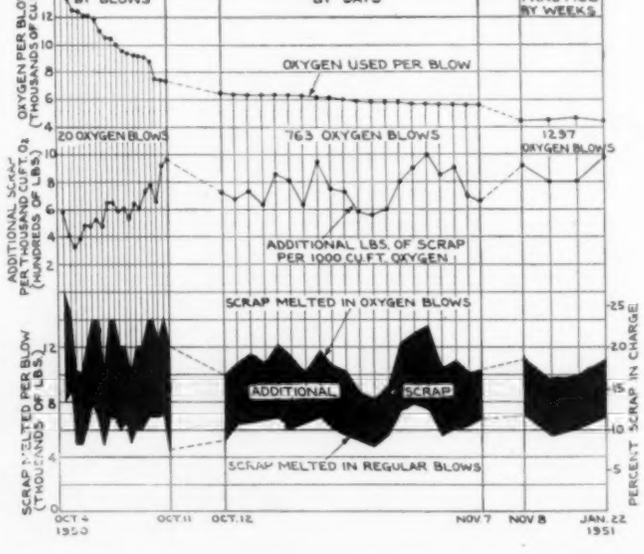


TABLE I

ESTABLISHED PRACTICE — RELATIONSHIP BETWEEN BESSEMER AND BLOWN METAL OXYGENATED BLOWS COMPARED WITH NON-OXYGENATED BLOW

	Oxygenated blown metal	Oxygenated bessemer	Regular
Pounds of steel scrap	10,000	11,000	6,000
Pounds of hot metal	50,000	49,000	54,000
Pounds — total charge	60,000	60,000	60,000
Cu ft oxygen consumed	4,000	6,000	—
Minutes blowing time	10	9	11
Time start oxygen into blast	Start of carbon flame		
Minutes oxygen used	4	6	—
Oxygen rate cfm	1,000	1,000	—
Per cent oxygen in total blast	22.1	22.5	21.0 (air)
Per cent scrap in total charge	16.7	18.3	10.0
Per cent silicon in hot metal	1.50	1.50	1.50
Hot metal temperature F	2,550	2,550	2,550
Additional lb of scrap per thousand cu ft oxygen	1,000	833	—

hot metal to be blown also reduces the blowing time, limiting the time in which oxygen can be introduced and efficiently used without leaving an excessively oxidized condition in the bath. The typical statistical relationship between oxygenated blows of bessemer and blown metal against a normal blow, under final established practice, is shown in Table I.

Figure 1 illustrates the efficiency of scrap melting in relation to the volume of oxygen used. The curves shown begin with the initial trials on an individual heat basis during the first week. The central portions of each curve represent average daily practice, after a nominal practice had been set up. The right hand portions of the curves represent weekly average practice after a definite method for using oxygen had finally been established. It will be noted that in reducing the oxygen per blow from 15,000 cu ft down to 4500 cu ft, the additional pounds of scrap melted per thousand cu ft of oxygen has been increased from about 400 up to nearly 1000 lb. Present practice indicates that within certain bounds, as outlined previously, almost 1000 lb of additional scrap can be melted per 1000 cu ft oxygen, with the upper limit being 5000 lb additional scrap per blow. These experiences also indicate that any use of oxygen above 4000 to 6000 cu ft per blow will reflect a wastage of oxygen, and possible overoxidation, adversely affecting quality, yields, and costs.

Indications are that the introduction of oxygen during the blow will produce a slag higher in iron oxide content, and more fluid. This is especially true when the oxygen is used in larger volumes and left on until near the end of the blow. These facts indicate a slightly higher loss of metal to the slag, which is partially counteracted by a lesser volume of slag through a decrease in the hot metal used.

Due to the higher FeO content of the finished metal and slag, manganese efficiency is slightly lower on oxygen blown bessemer heats than on regular heats. With close control of oxygen usage to avoid overoxidation, no ill effects have been experienced from the standpoint of steel quality as reflected in the subsequent manufacture of the finished product.

No effect on the nitrogen content of blown metal or finished product is evident from the various volumes of oxygen used in these experiments.

As the volume of oxygen per blow gradually has been decreased, the reduction in blowing time through the use of oxygen has become less pronounced. In early experiments using from 9000 to 12,000 cu ft of oxygen per blow, the blowing time was decreased by two to three minutes. Presently, with the use of approximately 4000 to 4500 cu ft of oxygen per blow, the blowing time is only about one minute less.

When oxygen is introduced into the blast, the flame immediately becomes more brilliant, and is further characterized by the increased volume of brown fumes of iron oxide breaking out of the upper portion of the flame. The higher the rate of oxygen input, the more pronounced these characteristics become. However, temperature indications, even with the oxygen on, still can be followed rather closely by the experienced blower.

"SIGNIFICANCE OF AIR TEMPERATURE IN OPEN HEARTH OPERATION"

By JOHN S. MARSH, Research Engineer

Bethlehem Steel Co.

Bethlehem, Pa.

▲ THE principal function of the open hearth is to supply high-temperature heat in amount sufficient to make steel. A useful approach to how it accomplishes this is through the notion of theoretical flame temperature, defined as the ratio of heat input to heat content of the combustion products. This ratio in greater, but incomplete, detail may be stated as:

$$\frac{\text{combustion heat} + \text{fuel sensible heat} + \text{air sensible heat}}{\text{total quantity of combustion products} \times \text{their mean heat capacity}}$$

It can be said at once that from one point of view, the problem of improved performance consists of increasing flame temperature. This can be accomplished by increasing the value of the numerator of the ratio, decreasing the value of the denominator, or both. The only important components of the numerator are heat of combustion of fuel and sensible heat of air. For a given fuel, the only independent variable is clearly air temperature. The denominator can be decreased by use of oxygen, which decreases the fraction of nitrogen, and can be maintained at minimum value by admitting only the quantity of air proper for combustion, since extra air joins the other gases of the denominator. The main sources of improved performance through increased flame temperature are then (1) use of combustion oxygen and (2) increased air temperature. This paper reports an inquiry into the second. The first step was to devise a means of measuring air temperature.

Measurement of the temperature of a gas is much more difficult than that of a solid or a liquid. However, one scheme is generally satisfactory. It consists of flowing the gas at high velocity over the thermocouple hot

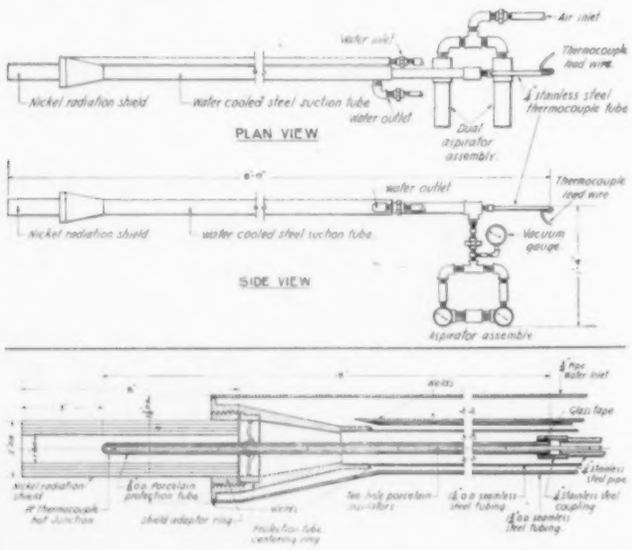
junction by means of an aspirator. The device is known variously as an aspirating pyrometer, a suction pyrometer, a high-velocity thermocouple, and by other names. In the form used by us, the thermocouple is protected from radiation by shields. Consequently, its precise description is multiple-shield, high-velocity thermocouple, which excessive compound is hereafter abbreviated to "velocity couple." Its general design is shown in Figure 1.

The velocity couple is used by insertion to about 40 inches through a hole in the uptake wall on the pit side, just above floor level. A transite sliding-fit shield blocks air leakage through that part of the hole not occupied by the device. The only reason for this site is that traverses of the uptake cross-section proved it to be as good as any. Hence, choice depended only upon providing least interference with routine furnace operation. Incidentally, this does not mean that gas temperature is necessarily uniform over the cross section, although it is substantially so in a properly operated furnace.

So far, data have been collected on air temperature for about 75 heats in about half as many furnaces in various shops. At the same time, information was gathered also in fuel and air flow, optical temperatures of uptake and checker walls, heat condition, air leakage, and so on. To simplify examination of the data, air temperature at an elapsed time of five minutes from reversal was chosen, somewhat arbitrarily, as being most representative of the air-flow period.

During accumulation of such data for a number of heats, it became increasingly clear that despite the many factors involved in determining the behavior of an open hearth furnace, the influence of air temperature dominates. To provide a ready means of comparison, the average of the five minute temperatures from the end of lime boil to tap was adopted. This was chosen because only during this period does air temperature reach a more or less steady level. For the 200-ton furnaces surveyed, each additional 100 F of air preheat means, on the average, about ¾ hr shortened heat time. Similar behavior was found for smaller furnaces and for various fuels. In other words, the hotter the air the faster is the heat.

Figure 1 — On top is shown plan and side view of velocity couple and on bottom is shown the details of the couple end.



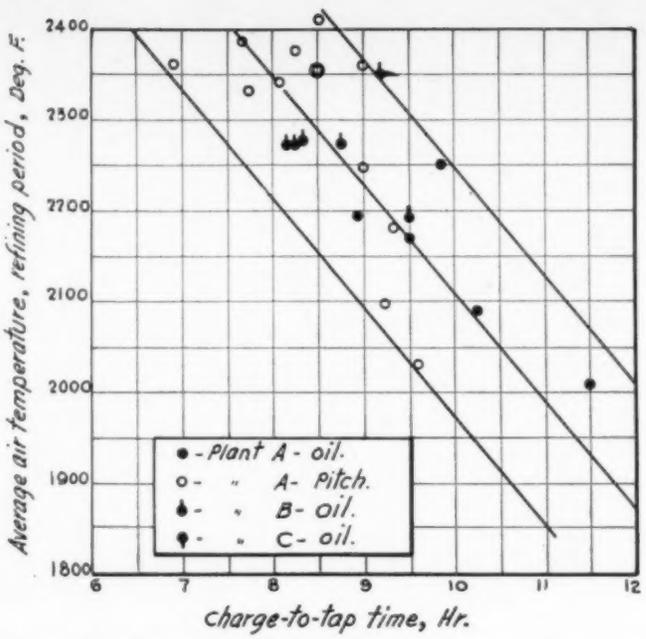


Figure 2 — Chart shows effect of air temperature on charge-to-tap time of 200-ton furnace which make 0.06 to 0.20 per cent carbon heats.

It is a matter of general observation that furnace performance is benefited by avoiding cooling as much as possible during the tap-to-charge period. This is substantiated by comparison of behavior during the charging and initial melting period with that during the refining period. The indication of gain of 175-200 F during the course of a heat means that full recovery from cold operation cannot be made in one heat. Thus, to maintain maximum productivity, a furnace must maintain its ability to preheat air. The most significant factor determining air temperature is, of course, temperature of the checkers. Comparison of air temperatures with checker temperatures (determined by optical pyrometer), however, revealed air temperatures ranging from several hundred degrees cooler to several hundred degrees hotter than those of the checkers. The latter means clearly that the regenerative system consists of more than the checkerwork — that fantails, slag pockets, and uptake walls are an important part of the system. The former condition can result only from air leakage, or infiltration. In a low-leakage system, air continues to gain temperature during its passage through the regenerative system, but this gain can be completely offset by air leakage. Such leakage must be increasingly damaging as its point of entry becomes later, since chance of acquiring preheat becomes correspondingly less. It may be deduced, then, that for a given furnace and fuel input, performance is governed principally by air leakage.

It was during the course of the infiltration versus air temperature study that we became especially aware of the fact that the velocity couple is as informative to its user as is the clinical thermometer in the hands of a physician. For example, our experience is that it is more reliable than infiltration as measured conventionally. We have seen furnaces stay slow after passing the test of routine infiltration measurement. These furnaces invariably showed low air temperature. Upon reslurrying, increased air temperature and faster heats followed.

"DIRECT REDUCTION OF IRON ORE USING THE FLUIDIZED SOLIDS TECHNIQUE"

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and
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▲ BRIEFLY, the fluidized solids technique consists of suspending finely divided solids in a moving gas stream. The gas stream not only suspends the solid particles but actually tends to separate the individual pieces. The rising movement of a gas at a selected rate through a given bed of properly sized particles results in a turbulent action of the solids material and in an expansion in the apparent bed volume. Generally, a fairly definite upper surface level is still retained by the "fluidized" bed. Because of the violent agitation of the upper surface the system resembles a boiling liquid in appearance and in many significant fluid properties. The term "fluidized solids technique" logically arises from the similarity to fluid behavior.

The direct reduction of iron ore is a gas-solid reaction. As such, the effectiveness of direct reduction processes depends on the extent of gas-solid contact that can be obtained. Since the fluidized solids technique provides excellent opportunity for gas-solid contact, it would seem ideally suited to direct reduction operations. In view of the apparent adaptability of the approach, an investigation was conducted in which some of the common iron oxide bearing material, that conceivably would be of interest to the steel industry, was direct-reduced, using the fluidized solids technique. The investigation was aimed primarily toward determining the effectiveness of the fluidized solids approach to the direct reduction of iron oxide bearing materials, and toward studying the problems that would be involved in trying to utilize the final reduced product.

In all direct reduction programs a problem arises as to the proper means for utilizing the reduced or partly reduced product. With starting materials of the type used in this study, the product is often neither sufficiently pure nor sufficiently well reduced to be used for powdered iron: and even if it were, only a limited tonnage could be used for this purpose. Insofar as the steel industry is concerned there appear to be only three possible outlets for the reduced product, namely:

1. As charge material for the blast furnace.
2. As charge material for the open hearth.
3. As briquetted into some finished and usable section.

While there is definite justification for considering partial reduction of iron oxide materials as an expedient designed to promote magnetic concentration, it does not seem logical to carry out more thorough reduction simply to prepare a product for the blast furnace. It is difficult to conceive of a situation where the direct reduction of iron oxide material prior to charging in the blast furnace can effect any overall savings in operating efficiency or costs. The finely divided reduced materials would have to be agglomerated to permit passage through the blast furnace. Moreover, another conversion cost would be involved in passing the reduced product through the blast furnace.

The third alternative must be discarded because the product is generally too impure and not sufficiently well reduced to permit pressing into a section with acceptable properties, and because briquetting techniques are not developed to the point where reduced iron can be pressed into usable sections on a larger tonnage scale.

It seems, therefore, that the only logical large scale use for the reduced product is as charge material for the open hearth. The open hearth process can utilize either a partly reduced product to replace some of the required charge oxide, or it could use a completely reduced product as a substitute for scrap.

Where the reduced product would be used to replace some of the charge oxide, the permissible gangue analysis must necessarily be low. Offhand, it could be reasoned that the weight of gangue compounds in the reduced product should not be greater than the corresponding weight in the replaced charge oxide. For most reduced iron oxide materials, this restriction means that some concentration operation must be carried out following reduction.

The fluidized solids approach to the handling of finely divided materials provides conditions of gas solid contact that appear ideal for promoting the reactions involved in the direct reduction of iron ores. Accordingly, a series of experiments have been conducted that were designed to evaluate the fluidized solids approach to the direct reduction problem. Reduction tests in the static and fluidized states were conducted on six different iron oxide bearing materials. The static tests provided basic data on the reduction characteristics of the various oxides, which, for the most part, simply support the results of many earlier investigations. The experimental procedures and the equipment used in conducting the fluidization tests often lacked refinement. However, the results of these fluidization reduction tests do provide an insight into many of the problems that are encountered in this approach to direct reduction.

In most of the experiments it was possible to obtain and maintain a fluidized system and to effect some reduction of the iron oxide. Under the conditions of this study, however, complete reduction was seldom approached and never attained. The best fluidization

TABLE I

BEST RESULTS OBTAINED IN THE FLUIDIZATION REDUCTION OF SIX IRON OXIDE BEARING MATERIALS

Material	Degree of reduction, per cent
Magnetite concentrate	64.8
Coarse taconite	91.0
Mill scale	81.8
Blast furnace flue dust	95.3
Hematite iron ore	89.0
Wash ore tailings	87.5

reduction performances for the six selected iron oxide materials are given in Table I.

With the exception of the rather unique materials which contained a very low percentage of gangue, the silica present in the reduced products was too great to be tolerated in any basic steelmaking operation. Considerable work was therefore carried out on the reduced flue dust and taconite products to determine the extent of silica removal that could be accomplished by magnetic separation. Through the use of complex schemes and at considerable sacrifice in iron recovery, it was possible to lower the silica in the reduced product to levels low enough to permit consideration as open hearth charge material.

With each material, it was possible to accomplish definite concentration with high iron recoveries. It can be concluded therefore that the fluidized solids technique does afford an effective means for roasting iron oxide materials to make them amenable to magnetic separation.

The utilization of the product from large scale direct reduction operations as charge material in the blast furnace or in steelmaking furnaces has been considered. It seems difficult to conceive of a situation wherein the expense of direct reduction by fluidization technique or any other sponge iron scheme can be justified for the production of a blast furnace charge material. (This conclusion does not necessarily apply to magnetic roasting for simple ore concentration.) In charging to steelmaking furnaces, such as the basic open hearth, it is conceivable that the reduced product could be utilized either as a scrap substitute or as a charge oxide. This work has pointed out some of the difficulties to be encountered in direct reduction for the manufacture of scrap substitute. A substitute charge oxide material could be obtained through incomplete reduction of iron oxide material. As compared to conventional oxides, the use of such incompletely reduced material would result in an increase in the iron units that could be charged to and recovered in a given furnace. The application of direct reduction procedures for the preparation of incompletely reduced oxides for charging to the open hearth might be difficult to justify for many materials.

Direct reduction schemes are repeatedly being publicized on the basis of rather nebulous claims of being capable of supplementing existing steelmaking capacity. It should be brought out that neither in theory nor in practice can direct reduction schemes be considered as methods for independent steel production. Under the best considered schemes, the directly reduced product must be further refined in some conventional steelmaking unit in order to convert the iron into a usable form.

"IMPROVING CURRENT PRACTICE IN BLAST FURNACE SINTERING"

By ROBERT E. POWERS, Fellow
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▲ AGGLOMERATING processes are growing in importance, as ever increasing tonnages of finely-divided iron ores are prepared for blast furnace consumption. Sintering is today's major iron ore agglomerating process. It is well established with a background of long experience. Sintering has served the blast furnace industry well for 40 years, first in conversion of waste flue dust to usable blast furnace ore, and lately in beneficiating burdens through elimination of fines.

The expansion of sintering facilities during the production activity of the last war and the postwar years has been remarkable. The capacity of installed plants is now estimated to be in excess of 28 million gross tons per year, whereas 10 years ago it was only 13 million.

Accompanying the increased importance of agglomeration and the rapid enlargement of sinter plant capacity, has come a desire to improve upon the quality of sinter and upon its methods of production. Blast furnace practice of the last few years seems to show that in many cases the use of sinter has not given the benefits which were expected of it. The original somewhat overdrawn claims of improvement in furnace performance have often not been substantiated. Sinter therefore is under scrutiny. Upon the outcome of comparisons between sinter and other agglomerated products may depend the future of the sintering process. The problem is therefore of great significance, in view both of large present investments in sinter plants and of the steel industry's intent to provide the best and cheapest agglomerated product to the blast furnace.

American Iron and Steel Institute recognized the growing necessity to improve sinter and sintering by its establishment of the Subcommittee on Agglomeration of Fines. This Subcommittee conducted a survey of current practice as a means of ascertaining facts and as a basis upon which to establish a program of improvement. An investigator spent about a year in visiting 15 sintering plants which had been chosen to be representative of the best modern practice. A large fund of information was collected.

The problem is threefold. First, what results can be obtained from the use of sinter of certain properties in the blast furnace? Secondly, what properties in sinter are desirable? And thirdly, how can sinter of the desired properties be produced? These three areas are, of course, closely interrelated. In all of them much remains to be learned.

Operators reported in the survey that, in general, results are not as satisfactory as desired. Improvement in a few cases is noticeable upon substitution of sinter for lake ores, but more often it is either unnoticeable or inconsistent. The broad result in most cases is a recovery of iron units in the sinter without additional benefits to furnace practice. Any improvements resulting from replacement of ore with sinter are either too small for operators to be certain of, or decidedly margined. There were two plants providing exceptions to these general conclusions. Here sinter forms an integral part of a beneficiated ore supply, and the overall results of the sized ores and many other factors are beneficial. Little opportunity, however, has been experienced at these plants for practice without sinter.

The normal percentage of sinter in the burden varies, in the plants surveyed, from 18 to 65 per cent. In most cases, this is governed solely by the relative quantities

of sinter and ore available when operating the sintering plant at full capacity. The sinter is usually split evenly among furnaces, or else the amount is controlled by transportation facilities. There is no plant using more sinter on one furnace than on another for reasons of improved performance.

The maximum sinter used at any of these plants has been 90 per cent, and this maximum ranged from 25 to 90 per cent. Comparing operation at the maximum sinter with that at normal sinter, in general no differences were detected. Some southern furnaces "tightened up" when the normal 23 per cent sinter in a burden of all-prepared ores was increased to 33 per cent. Other southern furnaces had shown maldistribution by "blowing through" when the normal 20 per cent sinter was increased to 50 per cent.

There was no indication at any plant surveyed of an optimum percentage of sinter in the burden, although the Republic Steel Corp.'s Cleveland furnaces are reported to operate better at 40 per cent sinter than at higher amounts for maximum production. Of course, all ranges had not been tested. This absence of an optimum at most plants is in marked contrast to earlier reports which had shown that the advantages of sinter increased up to a certain percentage and tapered off above that.

These experiences, when studied together, seem to indicate that sinter, as commonly produced and used at present, acts very much like ore of similar chemical analysis. In other words, its beneficiation has consisted largely in upgrading its iron content. The economic gain from its production, then, has been in many instances chiefly a matter of recovery of nonusable flue dust and sludge.

In the final analysis, of course, the only test of suitability of sinter is the operation of the blast furnace. The properties most commonly considered important are (1) size, (2) strength, (3) porosity, and (4) reducibility. It is significant that, in the survey, most blast furnace operators were not satisfied with the properties of their present sinters. The chief complaint was that the content of fines is too great. Other deficiencies were stated to be lack of porosity, too much fusion, too wide a range of sizes, too small an average size, and too low reducibility.

The chief criterion of successful sinter plant operation has always been production rate. The American plants surveyed produced at rates ranging from 1.95 to 4.08 net tons per 24 hr per sq ft effective grate area. As a matter of interest, German plants produced at a rate of about 1.7, Swedish at 1.1 to 1.9, Russian, according to a recent report, at about 2.7 net tons per 24 hr per sq ft effective grate areas. Production rate will continue to be an important cost consideration, but the overall lowest cost will require attention also to quality of the product and to the effect of such quality on blast furnace operation. The objective is to produce sinter of suitable quality at the maximum production rate.

Examination of plants and practices in making blast furnace sinter produces the impression that great improvements are possible in many directions. Sinter itself can be improved, both in its level of properties and in the uniformity of those properties. The plants and operating practices can be improved to give closer control, greater efficiency, and higher production rate. To summarize, a few recommendations may be made for plant design, plant operation, research and development, and blast furnace testing.

Plant Design

1. Reduction of air leakage.
2. More efficient sinter screening.
3. Gentler systems for cooling and handling sinter.
4. Sizing, storage, and controlling rate of return fines.
5. Elimination of fines from sinter before it reaches the blast furnace.
6. Dust elimination from both stack gases and working areas.
7. Distribution arrangements for a fluffier bed.

Plant Operation

1. Increased attention to uniformity of bed burning, even at the expense of production.
2. Education of operators to function of instruments, and better maintenance of instruments.
3. Vigilant maintenance.

Research and Development

1. Development of sinter quality tests for use as plant control methods and for evaluating experimental results.
2. Laboratory research aimed at improving sinter properties and determining effects of operating variables.
3. Plant survey of air and carbon on a typical sinter machine.
4. Development of control tests for carbon and moisture in feed to the sinter machine for use as operating aids.
5. Development of methods of screening ores to finer size.
6. Improvement of methods of mixing.

Blast Furnace Testing

1. Use of statistical methods for accurate appraisal of effects of sinter.
2. Incorporation of sinter quality tests as significant variables, in order to increase understanding of the importance of various properties.
3. Further investigation of effects of sinter containing added basic materials.

"TESTING OF SINTER"

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▲ THE visual appearance of sinter is hardly suitable as a criterion of quality within an individual plant, and it is even less suitable when two plants or two observers

are involved. The situation is reminiscent of that when by-product coke was first used in blast furnaces. At that time blast furnace operators wisely developed certain test methods for the properties of coke, which could be used to put numerical values on their complaints and allegations. These methods have been in use for some 20 years. They are far from ideal for measuring the important properties of coke, but they have been vastly more useful than mere verbal description and the background of information on their use is now available for making alterations.

It has never been the practice in the blast furnace industry to do much test work on the ores charged to furnaces, since ordinarily nothing could be done even if the tests showed unsatisfactory quality. With sinter, however, the quality can be at least partially under control. At present sintering plants are supplying sinter to the blast furnaces without specifications. This results partly from ignorance of what the most desirable properties of sinter are for the blast furnace.

Although the present state of knowledge does not reveal for certain which properties of sinter are important, years of operating experience have given leads in this direction and of course our best pathway is to follow such wisdom in selecting properties to measure. Blast furnace operators consider the most important properties to be: (1) size sufficient for retention in the furnace, (2) uniformity of size, (3) sufficient strength to retain the necessary size, (4) porosity, and (5) reducibility at least equal to that of ore. Direct measurements of size, strength, porosity, and reducibility may not prove to be the easiest or best control tests, but they are the most obvious ones.

By size is meant not only average size but also the spread in sizes and the content of fines. A regular screen analysis at a given point in a plant should serve as an indication of strength. It may be misleading, however, when the handling between sinter plant and the point of sampling is not rough enough to break up the very large lumps which are already fractured.

One simple chemical determination which sinter plants generally fail to make is the carbon analysis of fine sizes from the screen test. This should be useful as a control method for completeness of burning or to tell whether fine sizes are the result of breakage of sinter or of incomplete burning on the machine.

The strength of pieces of sinter is important for its handling to the blast furnace and also for its action within the furnace. These two environments are quite different, and results by a test designed for one condition might be entirely misleading when applied to the other. For convenience the two will be designated cold strength and hot strength.

The importance of porosity of sinters, agglomerates, and iron ores lies in its indication of the surface available for gas-solid contact. The fundamental property to be considered is surface, but porosity is taken as its indirect measure. Where differences exist in the pore sizes, large differences exist in the surfaces represented, so that equal porosities do not necessarily represent equal surfaces for gas contact. It is possible that direct measurements of actual surface by adsorption, such as are made on catalysts, might be useful, at least for research purposes. Some investigators have found correlations of their porosity measurements with reducibility measurements, but others have found no relationship.

A vast amount of published work exists on reducibility in relation to ores and sponge iron. A number of investigations have been reported on sinters and agglomerates. Many of the methods used seem unsuited for control purposes because of the equipment involved and the time required. The methods may be grouped under the reducing gases employed:

1. Hydrogen.
2. Carbon monoxide, bosh gas, or blast furnace gas.

The rate of reducibility is strongly influenced by particle size, and investigations have been made on many different screen fractions of samples from minus 100 mesh to $-0.742 + 0.525$ in.

A number of investigators have examined the mineralogical and crystalline composition of sinters by microscopic examination. At the Alan Wood sinter plant a microscopic examination has been used for control purposes. All the results to date indicate that microscopic examination may be a very valuable tool for research purposes, although by its nature it may not be so well suited for control work.

A need for control tests to definite sinter properties exists at sinter plants and blast furnaces. The literature records much pertinent information on such topics as size, chemical analysis, strength, porosity, permeability, reducibility, magnetic analysis, and microstructure. Since the properties desired in sinter are not yet understood and few plants have attempted to measure sinter properties, it has been possible at present only to point out a few of the methods which have been tried on laboratory scale and which appear promising for control work. By adapting some of these, the measurement of almost any desired sinter property could be accomplished.

"RECENT AND PROSPECTIVE SINTER PLANT IMPROVEMENTS"

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▲ ONE of the most recent additions to sintering plant equipment is the so-called sinter cooler which is installed at the discharge end of the sintering plant, outside of the building proper, under the end of the sinter discharge chute. It consists of a 48 ft diameter table, usually lined with refractory brick, on which is mounted a steel structure built in the form of a doughnut, which retains the sinter as the whole mass slowly revolves. An adjustable plow is mounted on a fixed structure at the desired location so that the sinter can be

scraped off onto a belt conveyor and then to bins or yard as the case may be.

Within the last year or so, at least eight of these revolving sinter coolers have been installed to handle the sinter from as many sintering machines. Although it is probably too early to form a definite opinion whether they are justified or not, they certainly have caused considerable discussion as to their merits. The present installations have not eliminated the use of water, although less is used than where no cooler is installed. One thing definitely can be said for the sinter cooler—it is a good feeder, with some cooling taking place.

Since the installation of the large sinter cooling tables, the size of the sinter has become important. Large pieces of sinter do not cool as fast as small pieces, and large pieces, discharged from the cooler, block chutes and damage belt conveyors. To solve this problem, a toothed roll has been installed in the sinter chute below the stationary grizzly. This is a single roll, the full width of the sinter chute, mounted on coil springs to allow for vertical movement with a minimum clearance of approximately three inches between the bottom of the chute and the tip of the roll teeth. As the sinter passes between the chute bottom and the toothed roll the sinter is broken up to the desired size.

One of the chief complaints of the blast furnace superintendent, as far as sinter is concerned, is that it contains too many fines, that is, material minus $\frac{1}{8}$ or $\frac{3}{16}$ in. Fines are not desirable in the furnace feed and it is immaterial whether they are unsintered raw material or fine sinter.

What can we do to eliminate the undesirable fines in sinter? Air cooled sinter is one step in this direction. But even air cooled sinter contains considerable fines. If these fines are detrimental and should be removed, the only answer is screening. In one of our most recent plants this is accomplished by taking the sinter from the cooler by belt conveyors to a 5 x 14 ft double-deck vibrating screen. The top deck is equipped with a heavy one-inch screen cloth and the bottom deck with $\frac{1}{8}$ in. screen. This of course eliminates most of the undesirable fines, but as every one knows, sinter is very abrasive and $\frac{1}{8}$ in. screen cloth has a very short life. The overs from each deck go to the blast furnace and the through portion from the bottom deck goes to storage bins to be fed back into the sinter mix.

To reduce handling, a number of recently built plants have bins above the high line transfer car track. Screened or unscreened sinter and lump ore from the ore screens are carried by belt conveyor directly to the bins.

In every sintering plant one of the dustiest and most hazardous handling problems is the feeding of flue dust from the receiving track hopper. A big step in solving this problem has been made through the installation of a gate, screw feeder, and a double shaft pugmill at the bottom of the hopper to control the flow of flue dust. The complete installation from receiving bin to the conveyor belt is dust-tight.

Sintering fan dampers have been manually opened or closed in the past, which has resulted in motor failures, due to starting and operating overloads. The newer plants have installed equipment to control electrically the setting of the damper. By means of limit switches the motor controls are so interlocked with the damper control that the motor cannot be started unless the dampers are closed. This has eliminated motor failures from starting loads as very few motors are large enough to start the fan with the damper open.

The most time consuming and expensive maintenance problem on the older type sintering machines has been the maintenance of the pallet corners. Due to the construction of the older machines — with their curved tracks, at both the drive and discharge end, designed so that the wheels traveled a true circle—pallet hub wear is considerable. The pallet corners rub as they go from the straight section into the curve or from the curve to the straight. In addition, the pallets are given a sharp blow on the corners as they drop over the discharge end. This condition has been eliminated in the newer sintering machines, but since it would require a major change to incorporate this feature on the old type machines, the next best thing has been done. This is to design the pallets with an easily removable lug at each corner which is held in place by the seal bar pin of the pallet. Where these removable lugs have been used, costly maintenance has been eliminated and their use on the older machine is highly recommended.

A number of mechanical improvements have been incorporated in the sintering machines which have been built during the past two years. The most important improvement, from a maintenance standpoint, is the method of guiding the pallets around the drive and discharge end curved tracks.

Another mechanical improvement on the sintering machine is the installation of radial sprocket teeth. The sprocket wheel has radial slots into which the shanks of the teeth are set. When a pallet gets out of step with the radial sprocket tooth, the bolts holding the tooth to the sprocket wheel shear and the tooth moves in toward the center and no damage occurs to the pallet. New shear bolts are inserted and tightened up and the machine is ready to operate.

All machines in the past have been rigidly constructed and no provision made for windbox expansion. Because of this rigid construction, wear and breakage has occurred when the machine became hot. On the new large sintering machines, an improvement has been made providing for expansion of the windboxes in either direction from a point approximately midway of the machine.

The standard sintering machine, for years, has been 72 in. wide and of varying lengths up to 127 ft. We have recently completed the construction of the world's largest sintering machine—it is 12 ft wide and 168 ft long over the windboxes and has an active hearth area of 2016 sq ft, compared to the 612 sq ft of the 72 in. x 102 ft machines in common use. Many new features have been incorporated in this machine to reduce maintenance costs. The advantages of the large machine are many, including lower operating costs, less air leakage, smaller building to house one machine than the equivalent hearth area in the 6 ft machine, one bin system, one loading point and numerous other advantages.

The swinging spout is the most common method of distributing the sintering mixture across the width of a sintering machine. The newest device is an electric-

ally vibrated pan conveyor. The use of a vibrating conveyor for feeding materials is not new but in this installation the application is unique. A 30 in. wide pan is installed across the width of the machine at an angle of approximately 60 degrees to the longitudinal axis of the sintering machine. The pan bottom is cut so that the discharge from the 30 in. wide pan is the full width of the pallet. Although this is the first installation of its type for feeding a sintering machine, the principle is very good. It has the advantage of depositing the charge loosely on the sintering machine and, due to the vibration, some segregation takes place, allowing the coarse material to roll to the grates.

"THE EFFECT OF SINTER ON BLAST FURNACE PRODUCTION AS DETERMINED BY ANALYSIS OF DAILY OPERATING DATA"

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▲ A recent survey of sinter plants indicates that many people have had great difficulty in determining the effect of sinter on blast furnace operation. The difficulty is clearly due to the fact that sinter is only one of many factors that affect furnaces. Many of these factors cannot be held sufficiently constant over a long enough period to find the effect of sinter easily. Problems of this nature can be approached from the standpoint of statistical analysis and sometimes a good estimate of the effect of a factor such as sinter, in this instance, can be obtained from the regular operating records.

Benefits from sinter would be expected to come in two ways. First, it would increase the iron content of the burden. Secondly, it would be expected to give more voids of a uniform character in the ore layers which should contribute to increased gas-solid contact in the stack. This should help to offset the loss of reducibility that usually results from the sintering process. Whether it actually does or not is still a question that remains to be answered.

The results given here are from a statistical study using 1000 daily values from No. 2 blast furnace at Hamilton, Ohio. The hearth diameter of this furnace is 18 ft and its capacity can be considered to be 800 tons per day. The chronological period covers the greater part of lining No. 4 (February, 1944 to March, 1948).

From analysis, it is indicated that 50 per cent sinter should decrease the material 400 lb, which in turn should increase production about 64 tons per day. By direct correlation of sinter with production, is shown that for each per cent sinter in the burden, the production increases 1.14 tons per day, which for 50 per cent sinter would be 57 tons per day. This is somewhat less than the amount estimated by the indirect method.

A statistical estimate cannot be exact. It can only be fixed between limits. The difference here could be due to the scatter of the data, but it may also indicate that the increased production due to sinter has not been quite fully proportional to the increase in iron content.

To pursue the effect of sinter from the efficiency viewpoint, the 1000 daily values referred to above, were split into two sets of 500 each, so that one set contained the low values of sinter and the other the high values of sinter. This did not give as great a difference in the level of sinter for the two groups as would be liked, but it was the best that could be done.

The results indicate no appreciable difference in production and coke rate between the low sinter set and the high sinter set. However, it took 1200 cu ft less of air per ton of iron in the case of high sinter, even with the per cent scrap slightly less. The average blowing rate also was slightly less for the higher sinters. Had it not been for the effect of these two factors, the production would have been 12 to 15 tons more per day for the higher sinters.

If the individual data for the two levels of sinter are studied separately, by correlation analysis, to find the effect of blowing rate on efficiency, it is clear that the two burdens function differently.

For the low sinter level, the most efficient blowing rate is near 54,000 cu ft, whereas for the high sinters it is near 51,000 cu ft. The peak production rate occurs at about 57,000 cu ft for the low sinters and at about 54,000 cu ft for the high sinters.

In this instance, it is rather clear that the higher sinter burden causes loss of efficiency to set in at a lower blowing rate. It would, of course, be very helpful and more convincing if an all ore burden set of data on the same furnace and same lining were available for comparison.

It is well known that most sinters reduce more slowly than ore. Consequently, a larger portion of it is likely to be reduced deeper in the furnace. This would cause an increase in solution loss and could result in loss of efficiency at a lower blowing rate as has been indicated above.

The foregoing results have been presented only as an instance and not as a general solution to the problem of sinter utilization for everybody. They do indicate, however, that serious effort must be exerted to find out what kind of sinter is best and how to make it, in order to obtain its ful potential benefit in the blast furnace.

"FUNDAMENTAL INVESTIGATION OF STEEL PLANT REFRACTORIES PROBLEMS"

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and
E. F. OSBORN, Professor of Geochemistry
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School of Mineral Industries
The Pennsylvania State College
State College, Pa.

▲ IN any high temperature operation, obtaining a suitable container in which to carry out the reaction

poses a problem. It is evident that the container first must be able to withstand the temperature without failing, but it must also have adequate resistance to chemical attack by reactants, adequate resistance to mechanical failure, and the container material must be available in sufficient quantities, at a cost deemed reasonable. All of these factors are of some importance in any process, but the factors of quantity available and cost become particularly important in the manufacture of steel. Refractories are consumed by the steel industry in such quantities that they may justly be considered a raw material of the industry. Steel plant refractories are composed dominantly of one or more of the oxides of silicon, aluminum, iron, calcium, magnesium, and chromium. The first four (or five, counting the two oxides of iron) are the four most abundant oxides in the crust of the earth, with magnesia probably the sixth most abundant oxide. Materials for steel plant refractories, either now or in the future, must in the main be mixtures of these six oxides, except that where a process is strongly reducing, carbon may be employed.

If, therefore, we are to improve the refractories used in the making of steel, either in respect to prolonging their useful life under present conditions of operation, or of increasing the temperature of failure so that higher operating temperatures may be used without serious increased refractories consumption, or both, we should learn all that we can about the system, SiO_2-Al_2O_3-FeO-Fe_2O_3-CaO-MgO-Cr_2O_3.

The most successful method of investigating a system of this type is that developed at the Geophysical Laboratory of the Carnegie Institution of Washington. In this laboratory, precise phase equilibrium relations have been obtained for many one, two, and three component oxide systems, and partial data have been published for more complex systems. This information, which incidentally was obtained in the interests of learning more about natural minerals, and rocks rather than about refractories, is a small start toward understanding phase relations in the seven component system mentioned above; but the data are of such a fundamental nature that their usefulness in the understanding and improvement of refractories is immense. The development of superduty silica brick, for example, resulted directly from an application of these phase equilibrium data.

The investigation which was described in the paper is concerned with phase equilibria in a portion of the system CaO-FeO-Al_2O_3-SiO_2, a system of four of the components of which steel plant refractories and the slags which attack them are composed. The present study has extended earlier work to lower silica compositions by investigating phase equilibria in the system $2CaO.SiO_2$-$CaO.SiO_2$-$2CaO.Al_2O_3.SiO_2$-FeO. We how have specific information with regard to liquidus and solidus temperatures and phase assemblages over most of the system CaO-FeO-Al_2O_3-SiO_2 which would be of interest in the study of reactions occurring during the manufacture of steel.

The most striking feature of the system CaO-FeO-Al_2O_3-SiO_2 is the low temperature at which a liquid phase appears in mixtures in the system, being commonly less than 1200 C. This accounts for the poor resistance of aluminosilicate refractories to attack by lime-iron silicate slags, while on the other hand the low liquidus temperatures make the use of such slags feasible.

"OPEN HEARTH CHARGE ORES"

By JOHN J. GOLDEN, Assistant to Vice President
Steel Production

and

HENRY E. WARREN, Jr., Assistant Gen'l Superintendent
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▲ IN general, the chemical and physical properties of an ore, which determines its performance rating as an open hearth charge oxide, are fairly well known. The ideal open hearth charge oxide would probably consist of hard, dense lumps of hematite ore, free of fines, with a size distribution ranging from eight-inch to one-inch diameter lumps. A high iron content is desirable since it is associated with high available oxygen. The presence of acid oxides such as silica and alumina is undesirable; on the other hand, moderate amounts of basic oxides such as lime, magnesia, and manganese oxide have no undesirable effect on slag-metal reactions. A moderate amount of phosphorus in the charge ore does not present a problem since the basic open hearth process is efficient in the elimination of phosphorus. However, the presence of any sulphur in the charge is undesirable, as sulphur elimination can be accomplished only at the expense of decreased production rates and increased furnace maintenance costs.

A condensed summary of the proposed specifications for basic open hearth charge oxides is given in Table I. The tentative specifications should serve as a guide in the treatment and segregation of ores for open hearth

TABLE I

OPEN HEARTH CHARGE OXIDE SPECIFICATIONS

Specified variable	Specification	
	Ore	Sinter
Size		
Maximum, in.	12	12
Minimum, in.	1	½
Fines, max 20 mesh, Per cent of total weight	15	10
Minimum bulk density		
Lb per cu ft	150	100
Natural analysis		
Iron	Not specified	Not specified
Silica plus alumina plus titania	8.0	8.0
Lime	10.0	5.0
Magnesia	5.0	5.0
Phosphorus	0.3	0.3
Sulphur	0.05	0.05
Combined moisture	3.5	0.5
Natural moisture	8.0	Not specified

use and ultimately lead to preparation of improved charge oxides for open hearth consumption.

During the past several years, extensive trials have been conducted at several United States Steel Co. plants with both "as mined" and "prepared" charge ores, for the purpose of evaluating their effect on open hearth production rates. The general procedure for comparing operating performances of charge ores was to charge one-half of the furnaces in the test shop with one grade of ore and the other half with a second grade for one-half of the month, and then the furnaces were reversed. Nearly all of the test runs covered a period of at least one month. Tons produced per melting hour were used as a basis for measuring operating performance. Vermillion lump ore was used for feed practice in all trial runs. All references to per cent of iron in the furnace charge refer to the relationship of hot and cold iron charged to the total metallic charge, including metallics from the charge ore.

A test run of Brazilian and nodulized ore gave an operating performance, as measured by tons per melting hour, 11 per cent higher for heats charged with Brazilian ore. Charge ore, feed ore and limestone requirements were considerably less for Brazilian ore charged heats.

We believe that it can be stated, without reservation, that Brazilian ore more closely approaches the ideal charge ore than any other ore in use in this country today. Brazilian ore produces the highest production rates and yields; the best control of melt carbon; the lowest bottom and bank delays; requires the least amount of ore, limestone and fuel; and is the easiest of all ores to handle through ore bins. In addition, Brazilian ore can safely be used with no practical limits on per cent of iron in the charge without danger of blowing or spills.

The nodules used in this test were probably typical of the product in general use in the industry, the physical characteristics being more of the nature of a roasted ore than a true nodule. Screening the product to eliminate the excessive amount of fines would provide a better material.

A considerable tonnage of domestic and imported magnetite ores is used for charge practice in the basic open hearth. Sweden has long been one of the principal suppliers of magnetite ore. A test run with Swedish Kiruna and nodulized ore indicate that Swedish Kiruna is somewhat inferior to nodules from a production performance standpoint.

A test run with Swedish Kiruna and Vermilion lump ore showed an advantage of 2.2 tons per melting hour, or approximately 11 per cent, in favor of the Vermilion ore.

Another test run involving Swedish Kiruna ore showed that Swedish ore was slightly inferior, with respect to tons per melting hour to Frontier ore. On the other hand, a test run in another company plant with a mixture of one-half Swedish Kiruna and one-half Frontier ore versus straight Frontier ore showed up to a 10 per cent increase in production rate in favor of the mixed ore.

In each of the foregoing tests, production performance with Swedish Kiruna was inferior to that of the comparison ore. This is rather surprising, as it may be observed from Table II that the Swedish ore should be quite satisfactory for charge practice. From the chemical composition standpoint, the Swedish ore is high in iron and low in silica and alumina, and in this respect is only inferior to Brazilian ore. With regard to size, distribution and absence of fines, only Brazilian and Vermilion ores are superior.

In passing, it should be mentioned that contrary to our experience, some plants in the industry are using magnetite ores, particularly Swedish Kiruna, with excellent results. The most logical explanation is that our experience with magnetite ores has largely been confined to large furnaces with a relatively deep bath. Other plants with smaller furnaces and shallower baths are able to charge less ore and, because of the shallow bath, the bottom heats up faster and the reaction be-

TABLE II

CHEMICAL COMPOSITION AND SIZE DISTRIBUTION OF ORES

Type of ore	Swedish Kiruna	Brazilian	Vermilion	Nodules	Frontier	Group 3, coarse
	Magnetite	Hematite	Hematite	Hematite	Hematite	Hematite
Analysis						
Iron	63.32	68.02	58.70	61.94	50.96	52.08
Silica	1.75	0.30	8.10	2.35	10.29	6.00
Alumina	1.54	0.43	2.67	4.18	3.49	1.54
Phosphorus	1.38	0.035	0.038	0.056	0.059	0.062
Sulphur	0.034	0.008	0.074	0.026	0.038	0.014
Lime	4.90	0.10	0.10	3.38	0.43	0.07
Moisture						
Combined	1.19	1.66	2.35	1.10	4.14	5.23
Natural	4.45	1.27	1.30	0.57	8.35	12.10
Size distribution						
Plus 1 in.	37.6	59.3	76.5	8.2	14.7	45.7
—1 in. to ½ in.	18.2	23.1	6.4	18.9	18.7	
—½ in. to 20 mesh	32.4	9.1	12.4	55.3	41.0	31.2
—20 Mesh	11.8	8.5	4.7	17.6	25.6	23.1
Bulk density						
Lb per cu ft	227.8	251.9	265.6	262.5	236.8	235.3

tween ore and metal proceeds without delay.

Sinter is widely used for charge practice with moderate hot metal practice. However, when the iron in the charge exceeds 55 per cent, especially with large furnaces, the use of straight sinter does not usually produce satisfactory results.

A comparison between Frontier and Group 3 coarse ore showed a little difference in the production rates obtained with these soft ores.

Within the last few years, a new product known as "blocked iron" has come into limited use as a charge oxide. This material is produced by combining fine ore with a binder and molding the mixture into a suitable shape. A comparison of production rates obtained with blocked iron and Group 3 coarse ore showed the former to be superior.

A direct comparison cannot readily be made between the different results exhibited in this report, because of the changes in other operating conditions which took place from test to test.

We would also like to emphasize the fact that we do not consider soft ores, such as Frontier and Group 3, to be the equal of lump ores, such as Swedish Kiruna, even though performance ratings are approximately the same. The use of straight soft ore with iron charges of over 63 per cent is usually avoided or, if necessary, the ore must be sandwiched between layers of scrap to minimize blowing. Obviously, Swedish Kiruna ores or similar hard ores have a distinct advantage over soft ores, due to their ability to perform satisfactorily with higher iron charges.

It has been found that an ore which works satisfactorily at a given pig percentage in a furnace of say 120 tons may be entirely unsatisfactory in a furnace of 225 tons. It is probable that this follows the fact that even though the pounds of ore per ton remain the same for the two furnaces, the relative time required to heat the center of a pile in the large furnace is more than twice the time required for the furnace of one-half the size using one-half the total amount of ore.

It has also been found that the results from the use of fine ore, such as Frontier, Swedish, and others, can be improved by mixing it with more lumpy ores, solely because of the effects created by opening up the pile of ore in the furnace. The more open pile allows the hot metal to mix more readily with the ore earlier in the heat time and also allows combined moisture to escape more easily, which in turn helps to eliminate violent blows in the furnace.

The relative depths of bath, firing rates, temperature of furnace at charge time, etc., would each have its different effect on the results obtained from the use of a given ore.

A detailed review of the data would indicate a variation of approximately 12 per cent in production rates from the various types of charge ores studied in these tests, most of which could be associated with the ores.

In view of the fact that the quality of ore and its physical condition can affect ingot production rates, it is quite apparent that there is much work yet to be done in the processing of the poorer grades of ore to a form that will provide consistently a charge oxide of suitable size and structure, which will lend itself to the maximum production rates and thereby eliminate one of the many variables that do affect ingot production rates.

"MODERN COAL CLEANING IN THE PITTSBURGH AREA"

By R. P. BREMNER, Mining Engineer

The Youngstown Sheet and Tube Co.

Youngstown, Ohio

▲ IN order to lower mine costs in the face of steadily rising labor prices, most operators have installed mechanical loading equipment. The change from hand to mechanical loading has made it necessary to cut, drill and break the coal to facilitate such loading, with the inevitable increase in roof impurities and overall amount of minus ¼ in. fines. Unlike hand loading, mechanical loading does not distinguish between coal and impurities. As a result, it is not uncommon in the Pittsburgh seam to find the ash impurities more than doubled by mechanized mining.

Introduction of continuous mining practices, although still more or less in the experimental stage, has shown that there may be a decrease expected in overall rock impurities over conventional mechanical loading equipment, but at the expense of still more coal and rock fines.

The practice of selective mining toward the production of only lowest sulphur content coals has been abandoned by most operators. The reason for this is simple: the low sulphur areas in existing mines have been largely exhausted, and it is belatedly realized that judicious conservation measures must be taken to insure some degree of "life of mine" uniformity in sulphur analysis before complete exhaustion of a given property. New coal properties now under development are being laid out with an eye to overall mining costs for the life of the property. Variations in raw coal analyses will have to be handled by the preparation plants.

Additional increases in freight rates from mine to consumer are forcing coal consumers to demand reduction of the transportation costs on noncombustibles to a minimum.

One of the most difficult problems is that of determining and balancing the increased cost of preparation against the increased value of the cleaned coal to the consumer. In other words, will the additional cost of improving the quality of the coal be offset by the increased capacities and lowered costs of outbound products from the steel mills.

Finally, the decision faces all operators of older plants as to what extent modernization of existing equipment is justified in order to counteract the rising costs of labor and maintenance.

Most of the new metallurgical coal preparation plants in the Pittsburgh area, having a raw feed of high and

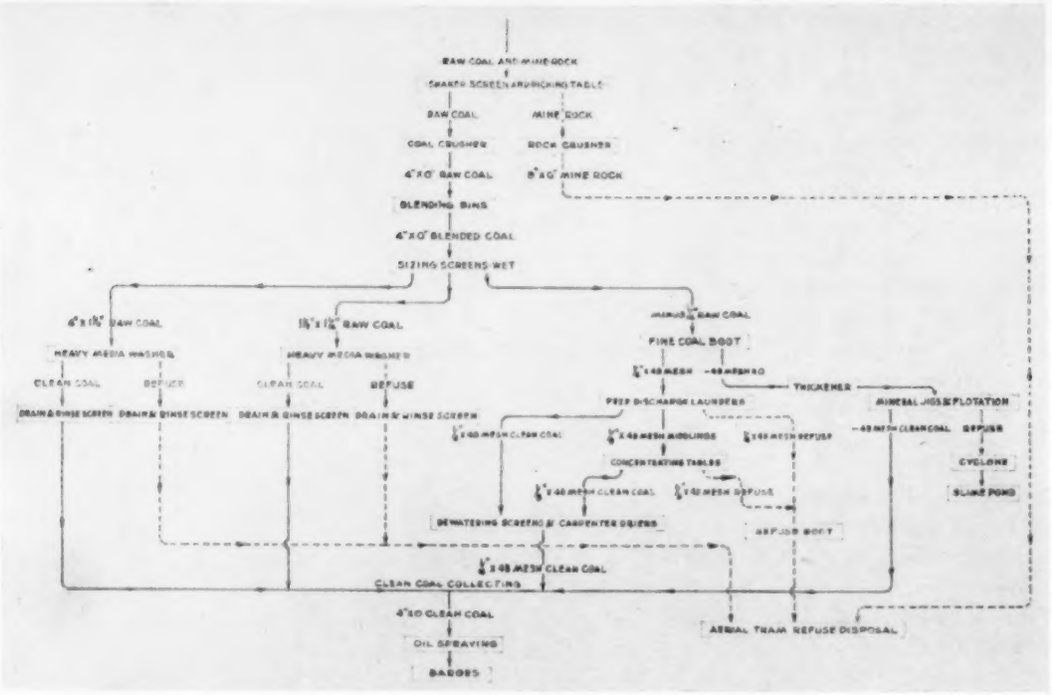

Figure 1 — Chart shows general flow of coal in Nemacolin plant.

variable sulphur content, possess similar general characteristics, but vary greatly in detail as to equipment. These may be illustrated by the flows of the modernized Mather and Nemacolin plants which are now going through tune-up and final construction stages. These flows, as shown by the block chart in Figure 1, include:

1. Facilities for picking coal from rock or rock from coal in the large lump sizes.
2. Coarse coal cleaning from 3 or 4 in. top size to approximately ¼ in. at gravities below 1.45, with provision to make a coarse coal middling which may be either used as is, or crushed and recleaned in the fine coal plant.
3. Cleaning of the approximately ¼ in. by 48 mesh size by launders and tables, and the minus 48 mesh size by diaphragm jigs and froth flotation.
4. Dewatering by using screens, centrifuges and filters.
5. Facilities for stocking raw or clean coal or both.
6. Blending bins.

These plants appear quite complicated since they incorporate seven actual cleaning circuits, a medium cleaning circuit, and water clarification circuits. Experience to date shows that these plants will do the job for which designed at high efficiencies. They are flexible enough to permit obtaining the desired grade of metallurgical coal despite variations in plant feed. Losses of coal to refuse have been reduced to a minimum. It is believed that these plants represent the most efficient combinations of methods now available for cleaning all sizes down to zero. Figure 2 gives the generalized flow arrangement of the crushing, picking and blending layout.

Studies of the sink-float tests on Nemacolin raw coal indicated that the coarse coal cleaning method for the modernized plant should be capable of washing at gravities as low as 1.35 or 1.40. The decision to install the Davis dense media process was based on our results

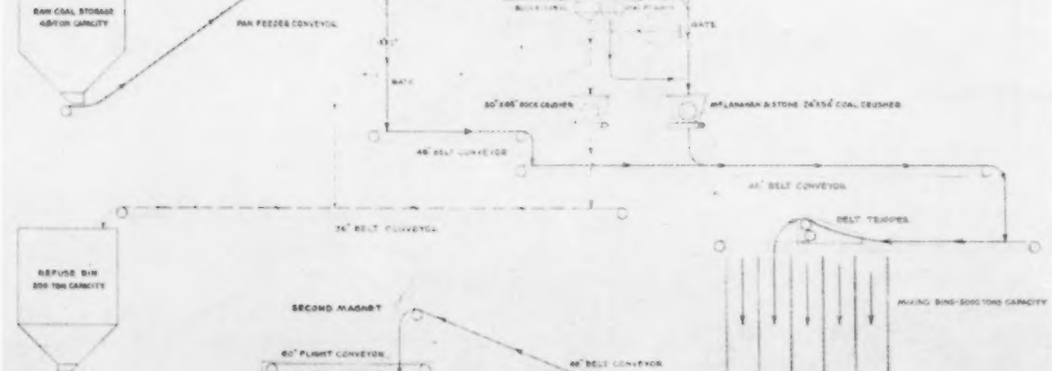

Figure 2 — Sketch shows flow sheet of picking, crushing and blending at Nemacolin.

and experience with the process at our Dehue Mine in West Virginia. The new Dehue cleaning plant has been operating successfully since the middle of 1949.

Although the Dehue raw coal is mechanically loaded, and contains about 16.0 per cent ash and 0.65 per cent sulphur, the shipped product is averaging close to 7.0 ash and 0.65 sulphur. This is accomplished in spite of the fact that the raw, minus ¼ in. fine coal, amounting to 35 per cent of the raw feed, is not cleaned. The No. 2 gas seam at Dehue carries an interbedded "boney" band, which is very high in ash. The "boney" is near gravity material and creates a very difficult washing job.

In the Davis dense media process, the medium consists of very finely ground magnetite in suspension in water. The specific gravity of the bath can be closely controlled to wash at gravities as low as 1.35 and as high as 2.00 in order to float the merchantable coal and sink the refuse.

Engineering studies indicate that, if present mining methods are continued, future analysis of raw coal at Nemacolin will remain approximately the same as the average for the year 1950. During this period, the raw feed from the blending bins to the washery averaged in percentages:

	Ash	Sulphur
4 x ¼ in.	26.48	2.41
¼ in. x 48 mesh	16.35	2.47
48 mesh x 0	21.55	2.97
Composite (4 x 0 in.)	22.88	2.45

The shipped coal 4 × 0 in. product of the cleaning plant averaged, in 1950, 9.30 per cent ash and 1.92 per cent sulphur. This essentially represents the cleaning of the original washer. The modernization program has not been completed as yet, although the new picking, crushing, and fine coal dewatering facilities operated in 1950.

It is anticipated that when the new coarse coal facilities, table plant, and froth flotation equipment are in operation, the cleaned coal will drop to approximately 7.0 per cent ash and 1.65 per cent sulphur. The moisture may be lowered slightly below the 1950 average of 6.20 per cent.

There exists an urgent need for better methods and equipment on certain phases of preparation. Fine coal screening is still inefficient and costly. Although there has been much improvement in the use of alloys and stainless steel screens, replacement is a major item in plant maintenance. Spraying at the coal face, to allay dust, adds much to the trouble of dry screening of fine coal. Continued research into the electric heating of screens is clearly indicated. The possible application of ultra-sonics to fine screening and dewatering is suggested as a subject for research.

Roofbolting offers some hope of reducing raw coal roof impurities.

Continuous mining methods, although lowering mining costs, will add to the burden of the fine coal cleaning plants by increasing the percentage of minus ¼ in. raw coal. Although existing fine coal cleaning methods are capable of operating efficiently at high gravities, very few, if any, are able to do a good job at low gravities. This need for continued improvement and new methods of fine coal cleaning is the current challenge to preparation research.

"PREVENTIVE MAINTENANCE PROCEDURES"

By J. B. WHITLOCK, General Maintenance Engineer
Armco Steel Corp.
Middletown, Ohio

▲ GOOD plant maintenance is more than upkeep. It is the right arm of management and plays a vital part in the operation from a profit and loss standpoint of all industry. It helps assure the continual flow of the finished product into the shipping department and thence into the customer's plant. The neglect or submergence of maintenance and its part in industry may well spell the end of an industry.

The National Production Authority makes the following statement in one of its directives on the "Use of Aluminum": "Maintenance means the minimum upkeep necessary to continue a building, machine, piece of equipment, or facility to sound working condition when the same has been rendered unsafe or unfit for service by wear and tear, damage, failure of parts or the like; provided, however, neither maintenance nor repair includes the improvement of any such item with a material of a better kind, quality or design."

The maintenance procedures I wish to present are ones which will not comply with this edict of the NPA. I cannot subscribe to its definition of maintenance or repair, and I wish to take issue with the final statement that "neither maintenance nor repair includes the improvement of any such item with a material of a better kind, quality or design." A progressive maintenance group must continually seek ways of making improvement and not be content to sit back and make similar repairs to a piece of equipment without effecting an improvement.

For your consideration I would like to suggest a few maintenance procedures which have aided in the maintenance of our properties. They have proved effective and perhaps they will suggest some plan to you which will be beneficial. These procedures may be called:

1. Inspection system of maintenance.
2. Failure research.
3. Lubrication.
4. Training.

The day of breakdown maintenance is now long passed. No longer can we permit the maintenance crew to wait in a shop for a whistle to blow, indicating that a breakdown has occurred. Ways must be found and systems employed which will minimize this "breakdown" maintenance procedure and place greater emphasis upon preventive maintenance to assure a greater period of delay-free operation.

In order to have such a preventive maintenance system, the supervisors of maintenance must possess, at all times, an intimate knowledge of the physical condition of the equipment that has been placed in their charge. Such knowledge can only come from inspection.

Following each inspection, the inspector should make a report, in writing, to the maintenance foreman of his section and whenever possible he should review each item of this report with his foreman so that a thorough understanding will exist. The maintenance foreman should then take this daily report and analyze each recommendation as to material requirements, labor requirements and time necessary for completion. After such an analysis has been made, the foreman can then build the maintenance schedules for his various crews.

"Failure research" is a phrase we have coined to describe one phase of our maintenance program which is proving very productive. This program simply involves one thing: asking why a piece of equipment failed and what can be done to prevent similar failures in the future.

Failure research may lead into design investigation, material research, and a study of operating practices in order to find the answer to this question "why." Usually the answer can be readily found and immediate corrective steps taken.

A study of maintenance costs quickly reveals the fact that sixty cents of each maintenance dollar is spent for materials. So aside from the preventive maintenance value received in an analysis of equipment failures, a possible reduction of material maintenance expenditures may be experienced.

The failure research program brought to light very quickly the fact that too many equipment failures were resulting from improper lubrication. These failures stemmed from too little lubrication, excess lubrication, lubricant failure and many other causes easily attributed to lubrication. The need for a corrective, intelligent lubricating program was very apparent. As a start, a lubricating engineer was employed and assigned to the general staff. His work was first to determine what was being done and what materials were being used in each division. Such a survey was made and eventually recommendations for improvement were made to each division. However, the problem of divisional administration was soon found to be necessary, so a division lubrication engineer was appointed in each location.

Improvement was apparent from the start as this division lubrication engineer started to exercise control. Correct lubricants were being applied by approved methods and at correct intervals, but no really keen interest was ever manifested by the employees assigned to lubrication work. They completed their daily assignments with mechanical motions only and took no interest in the results obtained. This attitude retarded the progress of our lubrication programs.

It was soon found that this employees' attitude was caused by a lack of understanding of fundamental lubrication principles. An intensive training program appeared to be a possible solution to this problem. A search was made for suitable text material with which such a course in lubrication could be taught. This search produced no satisfactory results but a mass of data was found that could be used if assembled. Such an assemblage was made and to it was added a great deal of material gathered from the experiences of the lubrication engineers.

No discussion on preventive maintenance is complete if it deals only with procedures and materials. There is a third element of such a program which is most necessary and most important. It alone can make the difference between a successful maintenance program and one that is a complete failure. This is the human element, its organization and training.

Today, the equipment maintenance demands are such that a well trained and precision minded personnel is a necessity. The sledge hammer mechanic is no longer in demand and fits into very few maintenance organizations. The type of organization to be employed may be one of many as each type has its own advantages. We used the assigned or departmental section, shops section and power section for our division of responsibility, and find it very satisfactory. Other systems or organization probably will prove to be just as satisfactory and efficient.

We are convinced that the preventive maintenance method is the only one that will even approach the demands of industry today and when this method of maintenance is intelligently applied — a reduction in both maintenance expenditures and maintenance delays is experienced. Many refinements to the four main points suggested to you may be made, such as shop scheduling, repair records of all major pieces of equipment, and incentive system of premium payment for all maintenance employees. However, these refinements must be built upon a sound, basic program based upon the four procedures suggested.

"STEEL QUALITY AS AFFECTED BY TRACK TIME AND SOAKING PIT PRACTICE"

By A. F. MOHRI, Chief Metallurgist
The Steel Co. of Canada, Ltd.
Hamilton, Ontario, Canada

▲ IN our plant, track time means the interval from finish of teeming to finish of soaking pit charging. In calculating the time soak, which is a metallurgical requirement, the time interval from start of teeming to finish of soaking pit charging is used. This is done to take into account any detrimental effects of excessively long teeming time.

Track time, except for calculating time soak, is made up of holding plus shipping and charging time. Holding time is specified by the metallurgical department and varies with the steel composition and mold size, and may range from 15 minutes to three hours. The steel must be sufficiently solidified to withstand shipping,

PIT PRACTICE AT CHARGE FOR ALLOY GRADES

TRACK TIME	PIT TEMP. AT CHARGE	MAX. TEMP. IN 2 HOURS
UNDER 3 HRS	1800 F	2100 F
3 - 3½	1700	2000
3½ - 4	1600	1900
4 - 5	1500	1800
5 - 6	1400	1700
6 - 8	1200	1500
8 - 12	Black Walls	Low gas flow not to exceed 600 C.F.M. for 1st hr., then gradually stepped up.
12 and over	Black Walls	Pit to be shut down ½ hr. then low gas flow for 1 hr. not to exceed 600 C.F.M. Additional gas in gradual steps.
OVER .70 PLAIN CARBON		
6 - 9 HRS	1600	1900
9 - 12	1200	1500

FOR ALLOY GRADES WHEN TRACK TIME IS OVER 6 HOURS, COOL PITS TO ABOVE CHART, OTHER TIMES COOL PITS AS DESIGNATED BY SPECIAL MEMO

Cold Killed Plate - Cool to 1200 F.

Charge alloy steel as soon as possible. Track time of low C nickel steels must not be over 2½ hours Use low gas flow at start.
Do not bank high stress steels such as - alloy, high carbon, high sulphur grades.

HEATING RANGES

TYPE	CARBON RANGE	TEMPERATURE RANGE
	0/05	Hot as possible without washing - 2350
RIMMED	06/09	2300 - 2325
	10/25	2275 - 2300
SK	04/25	2300 - 2325
	0/60	2325 - 2350
OPEN TOP	61/80	2300 - 2325
	81 plus	2275 - 2300
HIGH SULPHUR	ALL	Hot as possible without washing 2325 - 2350
	0/25	2300 - 2325
	26/50	2250 - 2275
KILLED	51/85	2225 - 2250
	85 plus	2200 - 2225
PLATE R.SK & OT	ALL	2325 - 2350
PLATE (HOT TOPS)	ALL	2325 - 2350

ALL STEEL HELD IN PITS FOR ABNORMAL PERIOD NOT TO EXCEED 2200 F FOR MORE THAN 3 HOURS BEFORE ROLLING.

MINIMUM TIME IN PITS

TYPE OF INGOT	FIN. POUR TO FIN. CHARGE	TIME HRS.
22 x 24 BEU	-	2½
23 x 25 BED		2½
Slab Ingots	Over 1 hr.	3
28 x 48		
26½ x 48	45'- 1 hr.	4
31½ x 31½		
26 x 53	30'- 44'	6

For 28 x 39 slab reduce above minimum times by ½ hour.

If any indication of "green steel" is noticed, stop rolling at once and hold for longer period.

Note: Time "finish pour to finish charge" applies to only minimum time in Pits. In all other cases "start pour to finish charge" is used. This is designated as "track time."

GAS SOAK

SIZE	TYPE	TRACK TIME	AMCO HR.	AMCO MIN.	OLD PITS HR.	OLD PITS MIN.
23 x 25 BED	R, SK & OT KILLD	-		45	1	30
22 x 24 BEU	HOT TOP K Spec.Grad.	UNDER 6 HRS		45	1	30
		OVER 6 HRS	2	00	2	00
	HOT TOP K Ord.Grad.	UNDER 6 HRS		45	1	30
		OVER 6 HRS	1	30	1	30
SLABS 31½-39" 48 -53"	R, SK & OT KILLD	UNDER 6 HRS		45	1	30
		OVER 6 HRS	2	00	2	00
	K (HOT TOP)	-	3	00	3	00

KILLED PLATE - Charge quickly into Pits. Not to be rolled unless fully soaked. If much cracking at 44" Mill, stop rolling and soak for longer period at higher temperature.
EL GRADES - Do not have any delays along roller line.

TIME SOAK

For Track Time under 3 Hrs. 15 Min.
Time Soak is Track Time Plus 15 Mins.
For Track Time over 3 Hrs. 15 Min.
Time Soak is Track Time Minus 15 Mins.
Track Time is start of Pour to finish charge.

Figure 1 — Soaking pit schedule in use.

stripping, and charging. Bridging over in hot top ingots and "cokey centers" (deep etch) in billets have been attributed to insufficient holding time. Alloy steel and high carbon hot topped killed steel require a longer holding time than lower carbon steel because of the greater spread in temperature between teeming and solidification.

The soaking pit schedule which is now in use is shown in Figure 1. In this schedule will be found the pit practices for the charging of alloy grades, the desired heating rates and minimum time in pits.

Track time plays a vital part in steel quality and also enters into the economics of the blooming mill operation. While production is outside the scope of this paper, it would be of interest to refer to the effects of track time on production costs, especially from a standpoint of fuel. Long track times will require long soaking pit times, and consequently can reduce the possible hourly production of the blooming mill. In our plant, the addition of a second locomotive to bring heats from the open hearth shop and remove the empty molds from the stripper reduced the average track time from approximately 3 hr to 2.7 hr and the fuel consumption of the soaking pit from 963,000 Btu per ton to 856,000 Btu per ton. This reduction in track time was reflected in a marked improvement in blooming mill tons per hr.

It is generally known that track time influences the quality of many steel compositions, especially from a surface quality angle. Track time does not appear to have much influence on most of the low carbon rimmed and semikilled steels. Such steels can be banked if necessary, and later charged into hot pits with a minimum amount of danger, while conditioning costs do not get out of line when compared with costs of ingots that were charged direct.

From experience with a wide variety of steel compositions over a number of years, we have established to our satisfaction that certain compositions are extremely sensitive to track time. For instance, rimmed low carbon resulphurized steels are particularly susceptible to surface irregularities when the heat has had a long track time and this type of steel should not be banked unless unavoidable.

Alloy grades containing nickel or molybdenum appear quite sensitive from a surface standpoint, while the straight chrome steels are less affected. AISI 9260, which is a silicon manganese steel, and the high silicon steels used in the manufacture of magnetic sheet steels, are very critical with respect to track time.

Long track time does not appear to affect most of the low carbon killed steels to any appreciable extent, except those with a chemistry of approximately C 1020 composition. Steels of over C 1080 composition, again, appear to become quite sensitive.

With a given soaking pit capacity, it is readily visualized that long track time because of "bunched" heats or other operating difficulties may result in a certain percentage of unsoaked steel being bloomed, which of course is detrimental to the steel quality, both internally and externally.

Piping on killed steels appears to increase with increased track time, which then adversely affects yields. When track time is high, thermal shocks are likely to be more severe on compositions having low thermoconductivity. Ingots of AISI 9260 composition are known to have cracked transversely in two or four equal parts when the temperature difference between the ingot and the soaking pit was excessive at time of charging.

High conditioning costs on alloy and high carbon steel

can most often be attributed to excessive teeming temperatures or extended track times.

Although a holding time is specified as a precaution against too early moving and stripping, there are instances where, from an operating standpoint, the ingots must be moved prematurely from the open hearth pit and therefore can arrive at the stripper too hot. Occasional difficulty is experienced in attempting to strip overly hot ingots. The ingot skin may not be sufficiently rigid, thereby allowing ingots to bind, or flow into the sides of the mold from the impact of the stripper crane tongs. A rough mold surface, under these conditions, may result in a certain amount of tearing of the ingot surface.

Short track time and rapid charging on arrival at the soaking pits are, as we all know, responsible for "green" steel. If the blooming mill is waiting for steel, a heat of this kind might not be solid and when such an ingot enters the mill, will adversely affect our yields because the semi-liquid steel flows out of the ingot and we are then confronted with large blisters on the bloom product. We have seen blisters at times 10 or 15 feet long on a slab.

In our plant when we refer to soaking in the soaking pits, we mean the heating of the ingot to a certain temperature and holding it at that temperature for a specified length of time. The temperature to which the ingot is heated is determined by the relationship of the analysis of the steel to the solidus line as shown in the iron-carbon equilibrium diagram.

Although generally a somewhat prolonged soak does no harm and in some cases improves quality, there are occasions where it is undesirable. Steel cast into bottle top molds or under-deoxidized semikilled steel can be adversely affected, since in these two types of steel the blow holes are close to the ingot surface and may become exposed by excessive scale formation. For this reason, every effort is made to keep the track time on these steels to a minimum, thus assuring a relatively short time in the soaking pits. High carbon and resulphurized rimmed steels which have a tendency towards thin skins require short soaking pit times.

The degree of decarburization that may be tolerated on the end product must always be considered. Long periods in the oxidizing atmosphere of the soaking pits contribute to a degree to the total amount of decarburization which may occur in the finished product. Certain heats on which the open hearth has experienced difficulty in teeming, may be benefited by long soaking in an atmosphere which is conducive to heavy scale formation. The heavy scale will remove small scabs and slivers and thereby assist in reducing conditioning costs.

An under-soaked ingot causes the blooming mill roller trouble because of the tendency to arc, which may result in cobbles with a subsequent loss in yield. Under-soaked ingots, as the name implies, have a large spread in temperature from the surface to the center. This temperature differential will lead to cracks and tears in rolling and adversely affect the conditioning costs.

High sulphur rimmed heats and heats having a low manganese/sulphur ratio will roll better if heated to a relatively high temperature. On steels which are hot short at certain temperatures, such as vitreous enamelling iron and low metalloid steel, we heat as hot as possible so that the last blooming mill pass will be made at temperatures above the hot short range.

Steel compositions that require high temperatures for rolling will be gummy and difficult to manipulate in the blooming mill. Temperature loss in manipulating this type of ingot will be high and it has been found that heating to slightly lower temperatures will actually result in higher finishing temperatures. This has frequently been experienced on three per cent silicon steels for electrical sheet manufacture.

The handling of steels that are susceptible to thermal shocks will be of interest. A system of priority charging has been based on the susceptibility to thermal shock. At times of bunched heats from the open hearth, there may be one heat which is critical and a schedule has been worked out so that the heats that are least affected by long track times will be charged last. Soaking pits are cooled prior to charging critically alloyed and high carbon heats. At time of charge, a pit temperature is specified which has been determined by track time. If reference is made to the soaking pit schedule, the column on the left will indicate the temperatures to which the pits must be lowered, which are based on track time before the ingots are charged. We have found this procedure to be extremely helpful in reducing our conditioning costs on the finished product.

"NON-CONTACTING THICKNESS GAGES FOR FLAT ROLLED STEEL PRODUCTS"

By W. A. BLACK, Chief Electrical Engineer
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▲ THE answer to needs for prompt and accurate information on the thickness of strip as it leaves the mill has been radiation gages. Two types have been developed and are in use. One of these depends upon X-rays and was first tried out on a steel mill in 1947. The other uses beta rays and was used experimentally on a mill in 1949.

Both the X-ray and beta ray gages use radiation energy directed toward one side of the strip. In one case, the source of energy is an X-ray tube, while in the other case the source is one of a number of radioactive isotopes. Some of the radiant energy is absorbed by the strip and some passes through it. The portion that passes through the strip and impinges on a detector or pickup device is used as a measure of the strip thickness.

Radiation devices for measuring thickness are now being used commercially on practically all metals that are rolled into strip form. Reports from the instrument manufacturers reveal that they are also used on many nonmetallics such as paper, rubber, and plastics. The numbers of these instruments used, or about to be used, are classified in Table I by types of products measured.

The primary reason for using these instruments is to reduce the off-gage product which is so troublesome to the industry in general. It is obvious that the lack of

TABLE I

DISTRIBUTION OF RADIATION THICKNESS GAGES BY PRODUCT MEASURED

Hot strip — steel	18
Cold strip — steel	33
Steel pipe	4
Nonferrous products	31
Nonmetallic products	23
Total	109

immediate gaging can in some instances result in a sizable tonnage of off-gage material. With a noncontacting gage at the exit end of the mill giving instantaneous information, the roller makes adjustments immediately and thereby gets the correct gage in the first slab. Also, radiation gages, by giving the roller immediate continuous information on rundown and crown, permit him to control the gage more accurately and thus reduce off-gage rejections.

In high speed cold mills, strip vibration makes contacting gages entirely inoperable. X-ray gages, because of their relative insensitivity to vibration of the strip are, to date, the only solution to this problem.

The product of most high speed cold mills is so thin that tolerances are expressed in ten-thousandths of an inch and gaging is consequently extremely important. In the continuous measurement of any thin moving strip, regardless of the speed, radiation gages provide an accuracy not easily obtained from magnetic or mechanical gages of any kind.

In the production of certain products, such as tin plate, disfigured surfaces due to contact thickness gaging are a common problem. The radiation gage is considered by some users to be the best solution to the marking problem in continuous gaging of tin plate.

X-RAY GAGES

Locations of gages vary considerably depending on local conditions and individual requirements. In the case of hot mills, the gage position ranges from 4 to 21 ft beyond the center line of the last stand. It should be as close as possible to the mill. The longer distances are necessitated by mechanical obstructions.

Cold tandem mill installations are all at the exit end of the mill, within five feet of the last stand. Plans have been made for certain installations at the exit side of the first pass. In such instances, the users believe the instruments will be more effective as control devices at the first rather than the last stand. If the roller has information on an abnormal strip condition at the first stand, he has more chance to correct for it than if he does not know about it until after the strip has left the last stand.

On tin plate shear and electrolytic lines, the location is usually dictated by mechanical convenience.

Some mill installations permit the gage to be moved all or part of the distance across the strip. This feature adds to the initial cost of the installation but it permits gaging of the strip at desired points across the width and, by removing the instrument from the mill, greatly facilitates servicing.

Other gages are rigidly mounted on the centerline of the mill. The reason is usually lower installation cost. However, in some cases high maintenance cost and excessive mill delays have led to the conclusion that the low first cost was false economy.

The majority opinion seems to be that, as far as gaging at several points across the width is concerned, the traversing feature is of little or no value. Crown is usually estimated closely enough for all practical purposes and it is not considered necessary to have a precise measurement. However, those who do use the gage for comparing edges and center are convinced that this comparison is a valuable aid in gage control. Theoretical considerations and the probability of changes in operator skill as well as product specifications make the traversing feature seem worthwhile in spite of the majority opinion.

Four different types of chart records are used:

1. Per cent deviation from an unrecorded standard thickness. The thickness standard used is usually written on the chart unless it can be accurately tied in by time and date with other records.
2. Standard or nominal thickness in inches in addition to the deviation from it in per cent.
3. Standard or nominal thickness in inches and deviation from it in inches.
4. Actual thickness in inches.

All manufacturers claim accuracies of two per cent or better. Micrometer checks on all circuits have confirmed this claim.

Reduction of outages is a problem which in the large majority of cases needs attention more than accuracy. Outages have resulted from many causes and have totaled from five per cent of mill time on the simpler installations to 90 per cent on one of the major cold mill installations.

BETA RAY GAGES

The beta ray gage is a relatively new development and has been in production use on a limited scale for only about one year. While it is similar to the X-ray gage in many respects, it has two important basic differences. In the first place, the radiant energy is in the form of beta rays instead of X-rays and secondly, its source of energy is a radioactive isotope instead of an X-ray tube. It is an excellent example of the industrial application of the by-products of our atomic energy development. While the use of an isotope simplifies the circuit, it also creates new problems requiring special attention. Among these are the ever present radiation, deterioration of the isotope, low penetration, and wide scatter of the beam.

The range of the beta ray gage is only a fraction of that of the X-ray gage. The maximum thickness that it can measure is 0.050 in. The reason for this is the low penetrating power of beta rays. Not only is the maximum thickness low, but the operating gap is also small. In no beta gage installation is the gap more than three inches, which compares with the smallest X-ray gage gap in use anywhere. The small gap is made necessary by the tendency of beta rays to fan out in a large arc. If the gap is increased, the percentage of rays hitting

the pick-up decreases rapidly, as does also the thickness of steel that can be gaged.

Most installations are used to gage a maximum of 0.020 in. For measuring up to 0.020 in., the isotope most commonly used is strontium 90 which lasts for several years. For measuring greater thicknesses, the isotope required is ruthenium 106 which will last only a few months.

Beta gages are used primarily in tin mill shear lines for purposes of classification. The small size of the instrument makes installation simple and inexpensive. No water cooling is required.

The accuracy of the beta gage has been maintained within one per cent. To achieve this accuracy, it is necessary to maintain the position of the strip in the gap at the same level as it was when the instrument was calibrated. Also, in order to compensate for isotope decay, it is advisable to check the accuracy at least once a turn by inserting in the gap samples of known thickness.

A third factor affecting the accuracy of the indication is the potency of the isotope. To insure accuracy, the radioactivity of the isotope must be checked at regular intervals. This is done by sending the manufacturer samples of special tape that have been exposed to the direct beam for a definite interval. The manufacturer measures the radiation effect and, when necessary, replaces the isotope.

Compared to X-ray gages, outages of beta ray gages in production use have been negligible. However, the number of beta ray gages in use in the steel industry is also small compared to that of X-ray gages. In one beta gage installation, the extremely low frequency of outages during its year of use was an important factor in the decision to order several more.

Noncontacting thickness gages must be calibrated separately for each type of material that is to be gaged. The radiation absorption characteristics of all the elements vary between wide limits. Consequently, a thickness gage set-up for measuring the thickness of a nonmetallic or a nonferrous material cannot be used to measure the same thickness of steel.

Steels are composed of a variety of elements and the absorption characteristic of a given analysis is the result of the combination of the absorption factors of the elements present. Fortunately almost all of the materials normally encountered in flat rolled steels have absorption characteristics differing but little from that of iron, or are present in such small percentages that their effect is negligible. Hence one calibration will serve for the vast majority of analyses.

The only elements which are used in flat rolled products and have a significant effect on the overall absorption characteristics are chromium, nickel and molybdenum. They are used in quantities that may affect the thickness indications as much as two per cent. An 18-8 stainless sample, for instance, gives a reading approximately two per cent high when measured in a gage calibrated for plain carbon steel. For accurate gaging on steels containing nickel, chromium and molybdenum, it is advisable to calibrate the instrument with samples of the material to be measured.

The temperature of the steel, as well as its analysis, affects the accuracy of radiation gage thickness measurements. The reason is that thermal expansion slightly reduces the amount of steel in the X-ray beam. At normal hot mill temperatures this error amounts to about two per cent. If the instrument is to be used on hot strip, allowance must be made for this effect when the gage is calibrated. Cold samples used for reference, calibration, or standardization should be about two per cent lighter than the hot strip thickness desired.

"CLEANING FERROMANGANESE BLAST FURNACE GAS"

By Messrs. C. A. BISHOP
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▲ THE dust found in ferromanganese blast furnace gas is of two types. One type, comprising about 20 per cent of the dust present, consists of particles above 20 microns in size which, from their analysis, appear to originate in the disintegration of the coke and ferromanganese grade ore in the furnace burden. This fraction of the dust is removed from the gas stream by a conventional dust catcher. The other type, which accounts for 80 per cent of the solids present in the gas as it leaves the furnace, is a typical fume, with particle sizes varying from 0.10 to 1.0 micron. This material is apparently formed by a process of vaporization and condensation, which explains its extremely small size. It is the presence of this material which renders the problem of cleaning ferromanganese blast furnace gas so vastly different from the cleaning of basic blast furnace gas.

The first step in the program was to define precisely the problem in terms of fume loadings, fume composition, gas flow, gas composition, and temperature, and to obtain several hundred pounds of the fume so that a process for disposal of the material could be developed and tested by laboratory methods.

On the basis of many tests, it was found that the fume loadings averaged about 7.5 grains per standard cubic foot.

TABLE I

SOME CHEMICAL AND PHYSICAL PROPERTIES OF FERROMANGANESE FUME

Manganese	15-25	per cent
Iron	0.3-0.5	per cent
Total alkali (as Na_2O and K_2O)	8-15	per cent
SiO_2	9-19	per cent
Al_2O_3	3-11	per cent
CaO	8-15	per cent
MgO	4-6	per cent
Total S (as SO_4)	5-7	per cent
Carbon	1-2	per cent
Apparent density	12	lb per cu ft
Particle size (average)	0.3	micron

The chemical and physical properties of a number of fume samples are summarized in Table I. It will be seen that the manganese content varies from 15 to 25 per cent. The unusually high alkali content of the fume, which was found to vary from 8 to 15 per cent, apparently results from concentration of the alkali originally present in the manganese ore.

The particle diameters of the fume were found to range from 0.1 to about 1.0 micron, the average being approximately 0.3 micron. Such fine particles present a problem in processing and in any other handling required for further treatment after collection.

The fume was also found to be pyrophoric. If heated to approximately 350 F and exposed to air, it begins to oxidize, with the liberation of considerable heat, slowly turning from a gray to brown color as the oxidation proceeds. During this color change, the manganese oxides originally present are further oxidized and the carbonates present are decomposed. This burning operation also increases the density of the fume and renders it less floury.

The data taken from a study of the gas moisture content and temperature variations in the blast furnace gas to be cleaned showed that the variation in the moisture content ranged from a low of 2 per cent to a high of 30 per cent, and that the changes in moisture content were usually very rapid.

The first step was to select the equipment for removing the fume from the gas. Our company had had some previous experience with a ferro-manganese gas cleaning plant which included a unit for the dry electrostatic precipitation of ferromanganese fume. The collection efficiency of the precipitators had been found to be satisfactorily high, although difficulties with companion equipment for conditioning the gas and for handling and disposing of the collected dust had forced the abandonment of the cleaning plant at that time. It appeared possible to redesign the gas conditioning sections of the plant and to develop a more positive method of fume disposal.

In the final plan, therefore, it was proposed to cool and condition the gas simultaneously by passing it through a spray tower of sufficient capacity to cool the gas from an average temperature of 700 F to 350 F by evaporation of water in the tower. The spray tower, which was to operate without any water effluent, would cool and humidify the gas, as had been shown in the previous work to be necessary to maintain smooth and efficient operation of an electrical precipitator. This method of gas conditioning, therefore, was adapted for inclusion in the pilot plant.

The second step was to develop possible methods of handling and treating the collected dust. It soon appeared desirable to take advantage of the pyrophoric character of the material since such a treatment increased the apparent density of the fume from about 12 pounds per cubic foot to about 30 pounds per cubic foot and rendered it less "dusty." It was also found that the burned fume was more easily wetted and could be formed into briquettes which did not disintegrate in water.

Since the fume was to be removed continuously from

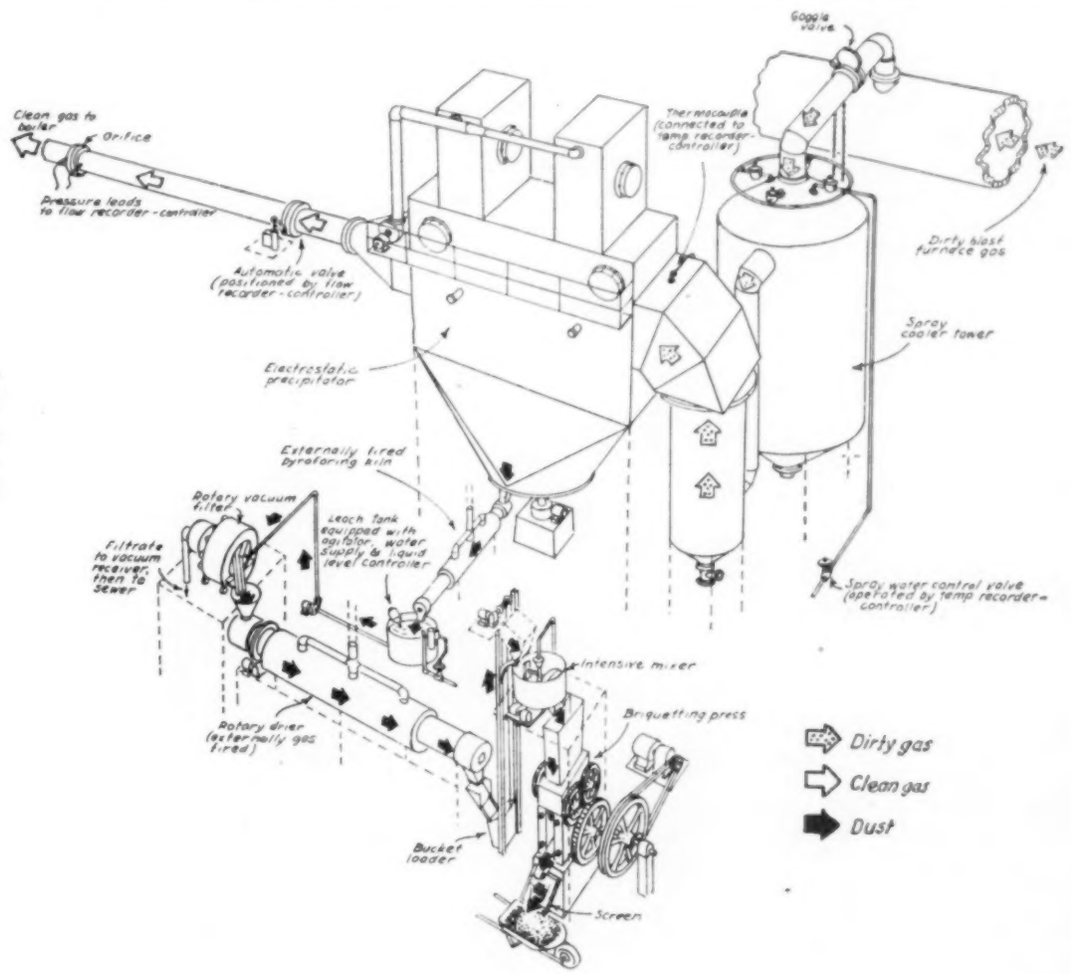

Figure 1 — Schematic diagram gives details of pilot plant for cleaning ferromanganese blast furnace gas.

the precipitator, equipment had to be provided for continuously burning the fume with a minimum of loss by dusting. The foremost function of such equipment, therefore, was to expose thoroughly all of the dust to air, since it was found that burning would not proceed deeper than about one-fourth inch below the surface of a standing batch of material. Both a vibratory-type conveyor and a rotary kiln permitted a good exposure of the dust to the air supplied for oxidation. Because the burning reaction is exothermic, and hence, self-sustaining in the presence of air, only a small amount of external heating was required to make up for heat losses. A kiln was adapted for use in the final pilot plant.

It was considered necessary that the fume be briquetted or otherwise agglomerated before it could be safely stored in any open area where prevailing winds might otherwise create an air pollution problem.

Experimental work indicated that water could be added to the burned fume and this mixture briquetted. Because of the difficulty of wetting the material, it was found impossible to disperse water through it evenly, simply by stirring. Various wetting agents were tried without success. As the work proceeded, however, it was found possible to mix water thoroughly into the fume by means of a muller. The quantity of moisture in the mulled fume-water mixture was found not to be critical. A moisture content range from 4 to 12 per cent produced satisfactory briquettes. The addition of Portland cement did not appear to increase the strength of the final briquettes.

A pilot plant was designed to clean 3000 standard cubic feet per minute of dry ferromanganese blast furnace gas in order to obtain sufficient clean fuel to fire one of the boilers in the plant. This represents about one-fifteenth of the gas produced by one blast furnace. Such an arrangement permitted a study to be made of the advantages to be gained at the boiler, made possible a visual guide as to the degree of gas cleaning attained, and provided approximately 190 pounds per hour of fume for further experimental processing.

The pilot plant, which was fully instrumented to permit the collection of sufficient data for design calculations for the contemplated full-scale installation, is described in some detail below. For a better understanding of its arrangement and operation reference should be made to Figure 1.

The pilot plant operation showed a visible effect of gas cleaning on the boiler stack effluent which was impressive. The stack of the boiler in which the cleaned gas was burned did not emit a discernible fume, while the others did. Although the loading of the cleaned gas entering the one boiler was about 0.12 grains per standard cubic foot, the stack effluent loadings were only about 0.05 grains per standard cubic foot because of the dilution of the gas with the air used for combustion. The cleaned gas burned with a short, bright blue flame.

Emphasis was placed on the operation of the spray tower, precipitator and pyrophoring kiln because their functioning comprised the more difficult phase of the process. Operation of the remainder of the plant was intermittent, but of sufficient duration to test the units adequately and to obtain the necessary operation data.

As a result of this work a plant has been designed to clean 135,000 standard cubic feet of ferromanganese blast furnace gas per minute.

"INCREASED PRODUCTIVITY THROUGH SAFETY AND ACCIDENT PREVENTION"

By HJALMAR W. JOHNSON, Vice President
Inland Steel Co.
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▲ IF we are to gain maximum productivity through safety and accident prevention, it is necessary to develop a program that will result in the minimum amount of time lost by personnel due to accidents. From this we can conclude that the ideal situation will exist when there are no accidents, with the result that no time is lost by employees from this cause.

We have found from experience at Indiana Harbor that the number of disabling injuries per million man-hours worked has decreased from an average of 21.82 in the period 1911 to 1920 to an average of 8.05 from 1941 to 1950. During the same period, the force in the safety office has increased from 0.43 man-hours to 1.28 man-hours per million man-hours worked in the plant.

These figures prove that the safety programs have been effective and certainly indicates that, as added time was spent in accident prevention, fewer accidents occurred. It is clear, however, that if further improvement is to be effected, it can be done only at the expense of time and money. From a theoretical and humanitarian viewpoint, such expenditures might be justified, but from a practical viewpoint, in the light of conditions existing today, they need to be questioned.

Perhaps there is justification for a more cold and bold approach at this time on the basis that the overall good of the people of the country is concerned, that the maximum amount of production is essential for survival, and for these reasons we are required to review critically the time and money spent on accident prevention against the time lost due to accidents. I believe the Army does it so and this is called "calculated risk." I believe the economists look at it in terms of "point of diminishing returns."

A tabulation of significant information for our Indiana Harbor plant for the month of January 1951 was prepared. This was a typical month during which the total of 407,408 eight-hour days were worked.

I do not arrive at any conclusions from these data. In an all-out war effort where maximum production was essential for maximum good, these figures might suggest that we are spending a disproportionate amount of time on accident prevention and that it might be worthwhile to accumulate further information of this kind. Perhaps with further good data it might appear advantageous to spend more or less time on accident prevention.

Personally I do not think the amount of time spent on accident prevention work is so important. What is important is how effectively we spend the time we do spend.

Time lost due to accidents:	Man-hours
Time lost by disabling injury, including time going to the hospital for treatment, etc.	6,496.0
Time lost for minor injuries	3,193.6
Other sources of lost time	52.5
Total	9,742.1

Time consumed in safety program to prevent accidents:	
Attendance at safety meetings	8,866.5
Attendance at accident investigations	451.65
Personnel in safety work	3,639.5
Safety training program	1,484.5
Excessive safety precautions	1,967.5
Preparation of reports, etc.	546.5
Staff meetings	108.0
Total	17,064.15

I would like to comment on some points we might class as "fringe areas" — areas where further attention might be worthwhile.

The first point I would like to make is that I feel there is a tendency to incorporate new ideas and practices into safety programs without careful consideration as to the results that will be obtained once they have been incorporated.

A second sphere of our safety program that I feel needs review is the training of our supervisors in safety, and in turn, their training of the personnel under them.

Another means of improving the effectiveness of the time spent on the safety program is to make sure that each member of management has a clear understanding of his responsibility in the safety program.

It is suggested that an analysis be made of the time spent on accident prevention against the time lost due to accidents. Breaking down the whole safety program into its constituent parts, allocating to each part the time it consumes and then critically reviewing this, may suggest means of using the time more effectively.

"INCREASED PRODUCTIVITY THROUGH TRAINING"

By JOSEPH S. KOPAS, Training Counselor
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Cleveland, Ohio

▲ CONSIDERABLE increase in production would result and many of the difficult and unpleasant human relations problems would disappear or become insignificant if every person employed by the steel industry were:

1. Placed on the job for which he was best qualified vocationally and in which he will have the best chance for success, progress, and enjoyment.
2. Trained to do that job correctly and safely, steadily, and conscientiously.
3. Provided with the type of leadership (supervision) and working conditions that would get the best out of him.

Since 1944 Republic Steel Corp. has screened vocationally every applicant employed so that we might improve the quality of our placement. We have adopted the policy of not placing anyone in any of our formal training programs such as apprenticeship and technical operating training unless the objective for which the person is to be trained is sound and feasible vocationally.

There are at least three vital areas that we must place at the top of the list of our daily efforts if we are to scientifically and conscientiously move ahead in improving the skill and the will of our employees to produce as much as we feel they should. We must:

1. Improve personnel actions.
2. Improve the quality of management skill in the front rank and management leadership skill in the middle lines of supervision.
3. Discover and develop persons of outstanding potentiality for key jobs in management.

Improving the quality of personnel actions — Each personnel action taken is of vital importance and concern to the employees involved because the decisions affect:

1. Their earnings and, therefore, their families' standard of living.
2. Their social standing among their fellow workers.
3. Their job security.
4. Their job satisfaction.
5. Their opportunity for maximum achievement
6. Broadening of their experience.
7. Their recognition.
8. Their further promotion.

Personnel actions are also very important to the company for obvious reasons, one of the most important being that of providing experience to the employees who will need and use it in the additional responsibilities the company will want to have them assume.

Too often such a personnel action is based on the decision of a lesser experienced and qualified member of the personnel department on the basis of a 10 to 15 minute interview, who turns him over to a supervisor who is too busy to train him, who then turns him over to some experienced worker who likely gives him a good dose of anti-management training and informs him how to get the most money for the least amount of work.

Improving the quality of front rank and middle lines of management — After we have placed the employee on the right job vocationally and have properly trained him in doing the job, it is doubtful if there is anything that would influence his willingness to work, build interest in his job, and develop loyalty for this company as much as the quality of leadership furnished him by management. Industry must depend on its front rank and middle lines of management for this leadership. The reason that management must depend on these two levels of supervision is obvious. They constitute approximately 85 per cent of the management personnel and they have the best opportunity to come in contact daily with the employees when and where it counts most.

Discovering and developing persons of outstanding potentiality for key jobs in management — About 2 per cent of the personnel of any company falls into the category of key management employees. This is a small number but the quality of management and the ability of the company to operate successfully and profitably and to progress depends on the effectiveness of this 2

per cent. To do their job well they should be the best personnel available from the standpoint of:

1. Vocational qualifications.
2. Training.
3. Experience.
4. Record of past achievements.
5. Character and personality traits.
6. Leadership ability.
7. Maturity and "stature."

If we do the job of vocational guidance and job training well, we will find considerable improvement in production and much more wholesome pattern of management-employee relations in our industry than we now have. A 1 per cent improvement in the productivity of the present employees in the steel industry is equivalent to adding approximately 6300 employees. A 10 per cent increase in the productivity would add another Republic Steel Corp. to the output of the steel industry. Adding to production of steel without adding men to the payroll, building new plant facilities and securing the necessary funds for expansion is a worthy objective.

"INCREASED PRODUCTIVITY THROUGH INCENTIVES"

By R. C. COOPER, Vice President in Charge of Industrial Engineering
United States Steel Co.
Pittsburgh, Pa.

▲ IT is a well established fact in the steel industry that extra performance can be secured for extra pay if the basis of the transaction is sound. The fundamental principle of the work and wage relationship is that the employee is entitled to a fair day's pay in return for which the company is entitled to a fair day's work.

The fundamental principle of the performance and incentive wage relationship is that, when regularly required on an incentive job to perform work over and above the requirements of a fair day's work, an employee is entitled to equitable extra compensation over and above a fair day's pay. The term "equitable incentive compensation" means extra compensation over and above the rate of a fair day's pay for the job in proportion to the actual performance required over and above the performance rate of a fair day's work on the job.

Such problems as we have encountered do not arise from the principles, but from the practicalities involved in applying the principles to the facts of each individual operation and the employee or group of employees involved.

The most significant lessons relate to three primary needs:

1. The need for effective management organizational arrangements to establish policy and handle the determination, application, and maintenance of performance standards and incentives.
2. The need for sound methods engineering, the prerequisite to the determination and application of performance standards and incentives.
3. The need for mutual understanding between management and employees and integrity of purpose as to the functions and proper use of performance standards and incentives.

These we list not in the order of their importance as related one to the other, but in the order of their necessary appearances, as we see it, if maximum potentials for increased productivity through incentives are to be realized.

The real job for industrial relations lies in generating the necessary mutual understanding between management and employees, and integrity of purpose as to the functions and proper use of incentives. Training is the watchword. To illustrate the point we will mention but a few items on which training is necessary.

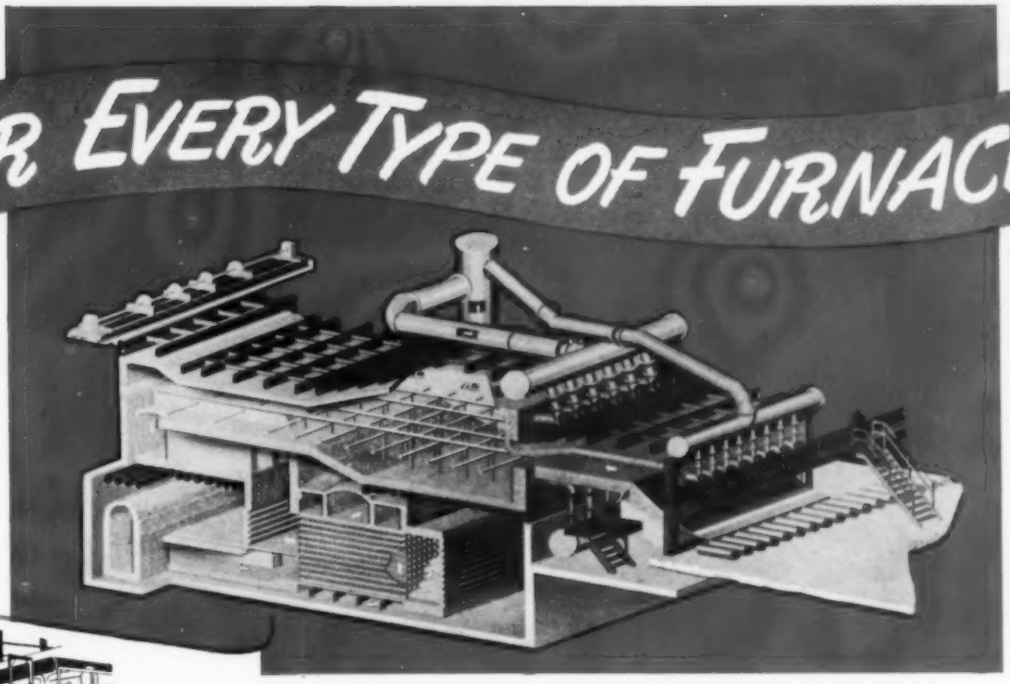
1. Training to both management and employees that the primary function of an incentive is to provide extra pay for extra performance. That means pay above a fair standard hourly wage rate in return for, and only for, measured and demonstrated return of work above a fair rate of performance, which is returnable to the employer before extra money is earned and payable.
2. Training to both management and employees that performance standards and incentives are applicable only where performance above a fair rate is needed and where performance can be measured with reasonable accuracy and practical consequence.
3. Training to management and particularly to industrial engineers that people generally do not like that which they do not understand and consequently an application of performance standards and incentives must be understood by both those who supervise the operation and those who perform it if the best results are to be obtained.
4. Training to management and employees that there must be an integrity of purpose and practice in the determination, application, and maintenance of performance standards and incentives.

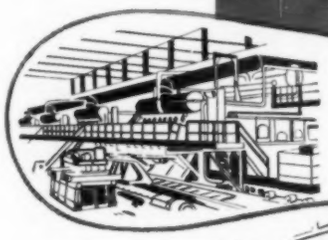
Our experiences prove that the maximum results obtainable from an incentive installation will be less than satisfactory to the affected employees and the company in any given instance that involves: (1) substantial waste of the employee's time through required idle time, avoidable delays, or the requirement to perform unnecessary work; (2) unbalanced distribution of work loads as between jobs of a crew or as between crews; (3) unnecessary or extensive abnormal effort; (4) needless exposure to abnormal working conditions or hazards; or (5) difficulties of operation caused by avoidable failures to provide effective facilities, equipment, processes, or services.

We have concluded that:

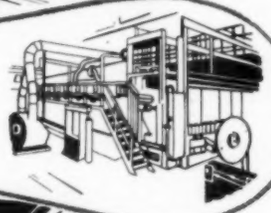
1. The factual determinations in industrial engineering problems form the foundation of yardsticks by which to pay people, plan operations, judge performances and regulate expenditures. Therefore, they are of fundamental importance to the welfare of the enterprise.
2. The determination and application of such yardsticks involve difficult matters bearing on the direct responsibilities of various administrative divisions of the company's management. Therefore, they require a high degree of inter-departmental cooperation.
3. The proper handling of this function requires: (a) full executive recognition of the necessities for such

FOR EVERY TYPE OF FURNACE

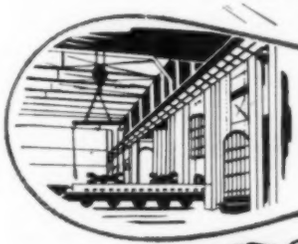




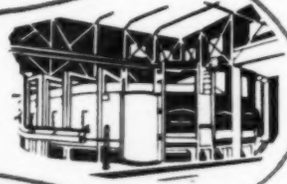
SLAB, BLOOM, BILLET, BAR HEATING FURNACES



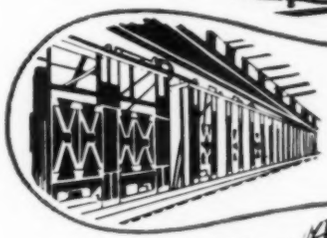
CONTINUOUS PIPE ANNEALING FURNACES



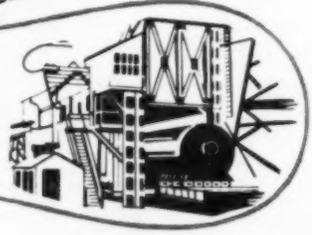
CAR BOTTOM TYPE HEAT TREATING FURNACES



ROTARY HEARTH, BLOOM AND BILLET HEATING FURNACES



BOX ANNEALING FURNACES



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F-2

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PITTSBURGH, PENNSYLVANIA

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service; (b) assignment of authority and responsibility for the interrelated parts of it to a single directing head with executive status; and (c) working arrangements within the management structure through which such executive may coordinate with, serve, and receive the assistance of the executive heads of the other management responsibilities having major related administrative interest, specifically operating, accounting, and industrial relations.

4. The function of industrial engineering must have the full backing of the company's chief executive.
5. The line operators who direct the operations and are called upon to produce the products at minimum cost must understand that such results can be accomplished only through their skillful use of sound industrial engineering determinations. They must be convinced of their ability to do a better job when proceeding on the basis of fact than when by rule-of-thumb.
6. The accounting people who must apply the results of the industrial engineer's factual determinations in the daily records and transactions of the business must participate fully in the development of policy and procedure through which those determinations are made. Their participation is needed to insure that the results thereof are subject to practical application and accurate adjustment for new or changed conditions.
7. The industrial relations people who are called upon to negotiate the industrial engineering findings that affect the daily lives of employees likewise must participate fully in the development of policy and procedure through which those findings are made. Otherwise the findings may not be fully negotiable or the negotiators may not be properly equipped for the discharge of their responsibility.
8. The industrial engineer must be qualified and willing to perform the work at hand. He must understand his function as that of technical service to facilitate the handling of other people's problems and therefore, must approach those problems with complete sympathy for the point of view held by those people.

"INCREASED PRODUCTIVITY THROUGH HUMAN RELATIONS"

By C. L. HUSTON, JR., President
Lukens Steel Co.
Coatesville, Pa.

▲ OUT of each successful company's knowledge of its business and determination to stand up against competition are evolved a number of sound policies which are used to guide the conduct of the business. Good human relations in industry start with sound industrial relations policies. Through various forms of communication these policies are made known within the organization.

The existence of sound policies is evident where a company management knows where it is going and makes decisions which are consistent to that end. Broad knowledge and acceptance of such policies by the organization as a whole builds a "climate" for good human relations in the business.

It is generally recognized that there are two simple fundamentals in good human relations: (1) everybody wants a sense of belonging, and (2) everybody wants to be appreciated as an individual. The better these desires are satisfied in industrial operations, the more satisfactory will be the resulting human relations. Employees who get a high degree of personal fulfillment in their work produce more easily, more efficiently, and with less phychological stress and strain which, once developed, is highly contagious in a plant community. Much depends on creating in the minds of employees the wish to produce fully, safely and efficiently.

An industrial relations policy is sound when it advances the economic strength of the company, when it convinces the worker he is appreciated as an individual, and when it makes him feel eager to be a working member of the "company-team."

When plants were small, it was comparatively easy for employer and employee to develop understanding and respect for a firm's industrial relations policy. Nowadays with so many huge plants, the close and friendly relationship which once existed between the company head and his employees on a broad scale is no longer possible. Enlightened managements, however, have realized the need for improvement and for an enlarged concept of human relations in their business.

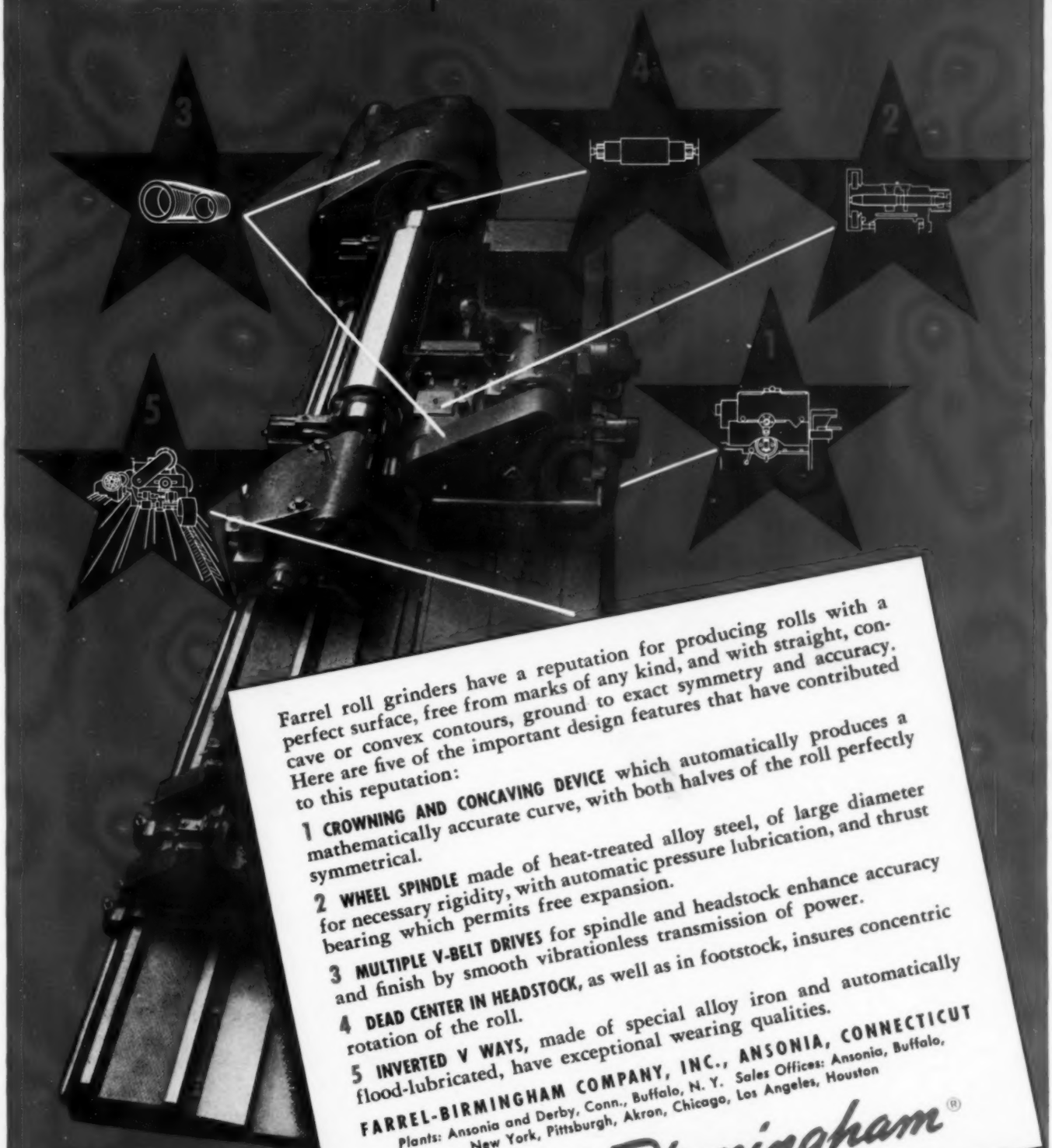
Already strides in the right direction have been made, first, to find out what employees are thinking, and then to analyze that thinking — especially with regard to employees' reaction to management policies. When employers find out what their people are thinking, they are taking a definite step in the right direction. Significantly, I believe management has found, in most instances, that what employees usually want is what management is ready, willing, and able to provide. Surveys have shown that, in addition to fair pay, reasonable working hours and satisfactory working conditions, employees would like to have information concerning the company, its financial health and progress, its production, its operation, its people and its policies. Likewise they desire to know something of the company's problems and what is being done to solve them.

The most commonly used medium for getting information to all concerned in a business organization is personal contact. Plant bulletin boards, the regular company news magazine, the company's annual report, letters from the president, public forums and many other media provide additional means of disseminating information.

Companies realize the importance of a man's family to his daily work. A growing number of companies are deciding that regular company mailings should be sent directly to the homes of employees where members of the family have first-hand access to them. Increased attention is being paid to make certain that employees know the end use of the steel produced by their workmanship. Constant thought and effort are applied to convince all supervisors from the president to the lowest ranking foreman that they are members of the management group.

Good communications invariably require that material be geared constantly to the interests and understanding of the employees.

AUTOMATIC PRECISION is a *five-star feature* of Farrel Roll Grinders



Farrel roll grinders have a reputation for producing rolls with a perfect surface, free from marks of any kind, and with straight, concave or convex contours, ground to exact symmetry and accuracy. Here are five of the important design features that have contributed to this reputation:

1 CROWNING AND CONCAVING DEVICE which automatically produces a mathematically accurate curve, with both halves of the roll perfectly symmetrical.

2 WHEEL SPINDLE made of heat-treated alloy steel, of large diameter for necessary rigidity, with automatic pressure lubrication, and thrust bearing which permits free expansion.

3 MULTIPLE V-BELT DRIVES for spindle and headstock enhance accuracy and finish by smooth vibrationless transmission of power.

4 DEAD CENTER IN HEADSTOCK, as well as in footstock, insures concentric rotation of the roll.

5 INVERTED V WAYS, made of special alloy iron and automatically flood-lubricated, have exceptional wearing qualities.

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Plants: Ansonia and Derby, Conn., Buffalo, N. Y. *Sales Offices:* Ansonia, Buffalo, New York, Pittsburgh, Akron, Chicago, Los Angeles, Houston

Farrel-Birmingham®

Farrel roll grinders are available in two types — type HD shown here, and type TT with traveling work table. Bulletins giving complete specifications of either type will be sent promptly on request.

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Morgan Mills-U.S.A.

REPUBLIC STEEL CORPORATION
1—24" Billet Mill
3—21" Billet Mills
2—18" Billet Mills
1—19" Billet and Sheet Bar Mill
4—18" Billet and Sheet Bar Mills
1—16" and 14" Merchant Mill
1—11" Merchant Mill
3—12" Merchant Mills
1—10" Merchant Mill
1— 8" Merchant Mill
4—10" Roughing Mills
1—10" Skelp Mill
1—18" Sheet Bar Mill
1—35" Blooming and Billet Mill
1—10" Wire Rod Mill
1—10" Merchant and Rod Mill
1—14" Strip Mill
1—22" Sheet Bar Mill
29 Mills

UNITED STATES STEEL CORPORATION
Carnegie Illinois Steel Corp.
1—24" Billet Mill
1—18" Billet Mill
1—16" Billet Mill
2—14" Billet Mills
1—10" Hoop and Cotton Tie Mill
1—13" Merchant Mill
1—11" Merchant Mill
1—10" Merchant Mill
1—18" Sheet Bar Mill
1—10" Rod, Tie, and Spike Rod Mill
1—12" Roughing Mill
1—10" Merchant and Strip Mill
American Steel and Wire Company
1—18" Billet Mill
1—13" Billet Mill
1—10" Strip Mill
3—10" Rod Mills
1— 9" Wire Rod Mill
Columbia Steel Co.
1—10" Rod Mill
Tennessee Coal, Iron & R. R. Co.
1—21" Billet and Sheet Bar Mill
United States Steel Co.
1—10" Continuous Bar Mill
23 Mills

BETHLEHEM STEEL COMPANY
1—30" Billet Mill
1—24" Billet Mill
1—18" Billet Mill
3—18" Billet and Sheet Bar Mills
2—12" Merchant Mills
3—10" Merchant Mills
1— 8" Merchant Mill
1—12" Skelp Mill
2—10" Wire Rod Mills
2—10" Wire Rod and Merchant Mills
1—10" Wire Rod Finishing Mill
18 Mills

JONES & LAUGHLIN STEEL CORP.
1—20" and 16" Billet Mill
1—21" Billet Mill
1—18" Billet Mill
1—21" and 18" Sheet Bar Mill
1—14" Merchant Mill
1—13" Merchant Mill
1—12" Merchant Mill
1—11" Merchant Mill
1—10" Merchant Mill
1—10" Skelp Mill
2—10" Wire Rod Mills
12 Mills

YOUNGSTOWN SHEET & TUBE CO.
1—24"-18" Billet and Slab Mill
1—24"-18" Billet Mill
1—14" and 18" Merchant Mill
1—12" Merchant Mill
1— 9" Merchant Mill
1—18" Sheet Bar Mill
1—21" Sheet Bar and Skelp Mill
2—10" Skelp Mills
1—10" Wire Rod Mill
1—10" Merchant and Rod Mill
1—21" Billet and Slab Mill
12 Mills

SHEFFIELD STEEL CORPORATION
1—19" Sheet Bar Mill
1—12" Roughing Mill
1—18" Billet Mill
2—10" Rod and Merchant Mills
2—12" Merchant Mills
7 Mills

FORD MOTOR COMPANY
1—32" Billet Mill
1—18" Billet and Sheet Bar Mill
1—42" Blooming Mill
1—14" Merchant Mill
1—10" Merchant, Rod and Strip Mill
1—12" Spring Mill
6 Mills

INLAND STEEL COMPANY
1—19" Billet and Sheet Bar Mill
1—24" Billet and Slab Mill
1—11" and 8" Merchant Mill
1—14" Merchant Mill
4 Mills

SHARON STEEL CORPORATION
2—12" Roughing Mills
1—21" Sheet Bar and Slab Mill
1—18" Strip Mill
4 Mills

COLORADO FUEL & IRON CORP.
Colorado Fuel & Iron Corp.
1—10" Rod Mill
1—12" Merchant and Skelp Mill
Wickwire Spencer Steel Co.
1—18" Billet Mill
1—10" Rod Mill
4 Mills

LACLEDE STEEL COMPANY
1—12" Roughing Mill
1—10" Rod Finishing Mill
1—10" Rod Mill
3 Mills

PORTSMOUTH STEEL COMPANY
1—18" Billet and Sheet Bar Mill
1—10" Wire Rod Mill
2 Mills

ATLANTIC STEEL COMPANY
1—14" Billet Mill
1— 8" Bar, Hoop, Tie and Rod Mill
2 Mills

PITTSBURGH STEEL COMPANY
1—18" Billet Mill
1—10" Wire Rod Mill
2 Mills

JOHN A. ROEBLING'S SONS CO.
1—18" Billet Mill
1—10" Wire Rod Mill
2 Mills

WEIRTON STEEL COMPANY
1—21" Billet Mill
1—18" Billet and Sheet Bar Mill
2 Mills

WISCONSIN STEEL COMPANY
(Sub. of International Harvester Co.)
1—11" and 8" Merchant Mill
1—16" and 14" Merchant Mill
2 Mills

ACME STEEL COMPANY
1—10" Hoop and Strip Mill

ALUMINUM COMPANY OF AMERICA
1—10" Merchant and Rod Mill

KEYSTONE STEEL & WIRE COMPANY
1—10" Rod Mill

OLIVER IRON & STEEL CORP.
1—11" Merchant Mill

PITTSBURGH CRUCIBLE STEEL CO.
1—12" and 8" Merchant Mill

WICKWIRE BROS.
1—10" Rod Mill

NATIONAL TUBE CO.
1—19" Skelp Mill

In addition, customers in other countries have purchased 66 Morgan Mills

MORGAN CONSTRUCTION COMPANY
WORCESTER, MASSACHUSETTS

English Representative: International Construction Company
56 Kingsway, London, W.C. 2, England

RM-58

MORGAN
WORCESTER

ROLLING MILLS · MORGOIL BEARINGS
WIRE MILLS - GAS PRODUCERS - AIR EJECTORS
REGENERATIVE FURNACE CONTROL

ANALYZING BLAST FURNACE GAS

▲ The GP blast furnace gas analyzer and alarm was developed by the engineering department of General Power Plant Corp. to fill the requirements of one of the large steel mills to supervise the blast furnace gas, thus providing a continuous record of the dust in the gas and an alarm to advise the operator when the dust concentration exceeded the allowable limit.

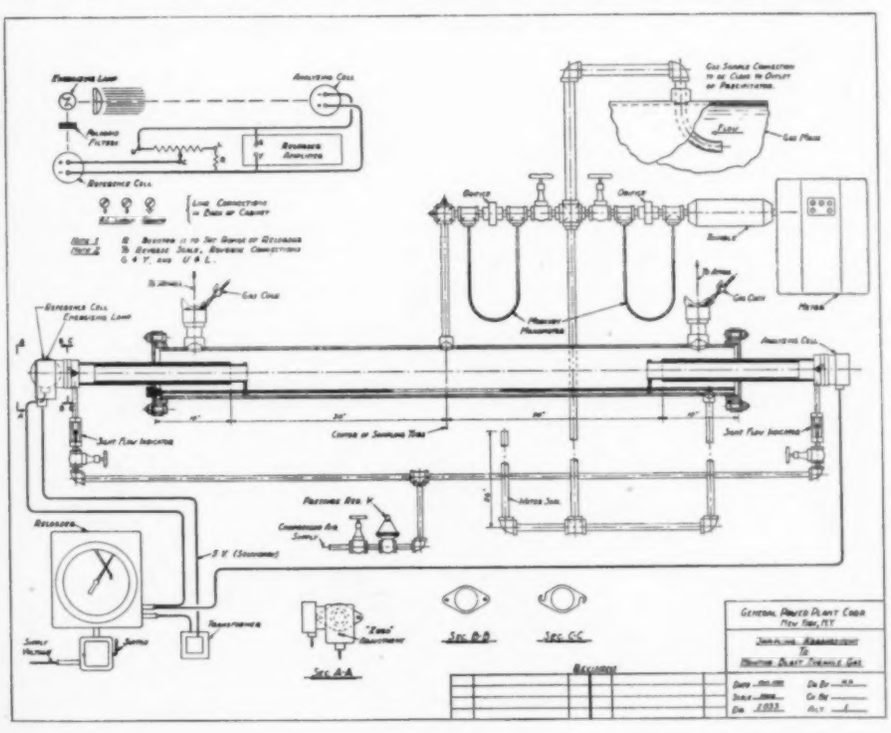
The first unit was put into operation September, 1950 and it has given satisfactory results ever since. Some changes to improve the rigidity and the accessibility were incorporated in additional units but experience has not suggested any fundamental improvement.

Since this gas is poisonous, the entire assembly must be gas-tight and secondly, because the gas is saturated with water, it is necessary to protect the lens on the lamp and cell from any accumulation of moisture. Figure 1 shows the general arrangement of the entire assembly and the principal dimensions. The gas sample is introduced into the center of the main tube and flows either way to the exhausts where it is burned. The outlet is large in relation to the inlet because it is necessary to keep the pressure constant in the sampling tube. The use of the large exhausts keeps the sampling tube at practically atmospheric pressure.

In the photoelectric type of analyzer, the velocity of the gas through the sampling tube is not important — it must move fast enough to keep the dust in suspension and to keep the sample representative of the gas in the gas main at the time the sample is recorded. For this reason the sampling tube should be located close to the point at which the sample is removed from the main. There is no reason for housing anything except the recorder.

The recorder is a special electronic circuit that measures the difference in output between two photronic cells. One cell receives the light directly from the energizing lamp while the second cell receives its light through the gas being analyzed. This circuit eliminates any error caused by line voltage variations on the energizing lamp. The recorder circuit is also compensated for variations in line voltage.

Figure 1 — Schematic diagram of arrangement used to analyze blast furnace gas.



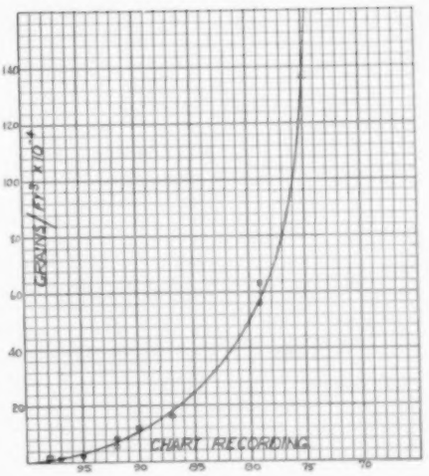


Figure 2 — Typical calibration curve for blast furnace gas analyzer.

To measure very dirty gas it is necessary to reduce the length of the sample to keep the reading on the chart. This is accomplished by sliding the inside sleeve (a 2⅜-in. tube) out of the 2½-in. lamp and cell support tube. In this way the length of the sample can be reduced from 60 to 20 in.

The recorder necessarily must be calibrated for each type of gas and for each setting of the sampling tube, i.e. the width of the sample. The width of the sample is altered depending on the average density of the gas to make the pen record nearer the outer edge of the chart. For relatively clean gas this width is 60 in. — for very dirty gas it may be reduced to 20 in.

The calibration is accomplished by measuring the actual solid content of the gas, using the familiar thimble and weighing the content. The start and finish of this test is noted on the recorder chart with the number of the thimble. The actual weight of solids is then compared to the average chart reading.

These results are plotted on a graph — chart readings vs weight of solids and a smooth curve drawn through the points. A typical calibration curve is attached. In this case, the width of the sample was 60 in. It will be noted that this sample width is suitable for densities up to 0.012 grains per cu ft of gas at atmospheric pressure.

DOWELL SERVICE

CHEMISTRY APPLIED TO MAINTENANCE CLEANING PROBLEMS

Dowell Service cleaned over 600 feet in THREE WORKING DAYS!

Coke oven gas is supplied to a large mid-western strip mill through 30-inch gas mains from the company's coke ovens two miles away. Deposits had accumulated in a 600-foot section of this line until the pressure drop had increased to double that of a clean line. Previous cleaning attempts were unsatisfactory . . . then Dowell Service was called.

With specially designed high-pressure jets and mobile high-pressure pumps, Dowell Service cleaned the dirty section in three working days. *There was no dismantling and Dowell Service did not interfere with the regular function of the gas line!* Trained Dowell engineers planned the job for utmost *safety, speed and economy.*

Boilers, blast furnaces, cooling systems, stoves, water lines, gas washers and many other types of equipment in the steel industry can be effectively cleaned with Dowell Service. Dowell engineers fill or spray the equipment to be cleaned with liquid solvents that are designed to penetrate and clean places inaccessible to other methods. Costly dismantling is eliminated and downtime is shortened.

Backed by tested equipment and experience in many jobs, Dowell engineers will be glad to consult with you on *better, faster* methods of cleaning your industrial equipment. No obligation . . . just call the nearest Dowell office today.

Other recent Dowell jobs:

Mud-like sludges consisting of calcium carbonate, iron oxides and iron sulfide were Dowell-cleaned from a blast furnace gas scrubber in four hours. Result: Pressure drop decreased from 22 to 7 inches of water.

•

The ammonia liquor cooling coils in a coke works became heavily encrusted with iron oxide scale. These deposits were removed by Dowell Service without interrupting operations. Result: A daily savings in coal and steam of $167.28.

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The checkerworks in a blast furnace stove were 98% clogged with broken tile and fused material. With special high-pressure jet equipment, fast Dowell Service cleaned the checkerwork openings completely.

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Wilmington 99	Chicago 4	New Orleans 12	Borger, Texas
Richmond 19	St. Louis 8	Ft. Worth 2	Midland, Texas
Jacksonville 2	Indianapolis	Shreveport 69	Wichita Falls, Texas
Atlanta	Louisville	Anniston, Alabama	Lafayette, La.

Long Beach, Oakland, Casper: Dowell Associate—International Cementers, Inc.

★ *Maintenance cleaning service for industrial heat exchange equipment.*
★ *Chemical services for oil, gas and water wells.*
★ *Magnesium anodes for corrosion control.*

DOWELL

A Service Subsidiary of
THE DOW CHEMICAL COMPANY

Date-line Diary...

July 1

▲ The AISI is not revising the rated capacity of the steel industry and official capacity for the remainder of the year remains 104,229,650 tons.

▲ A new bed of high-grade iron ore has been discovered about 100 miles from Sao Paulo, Brazil.

July 2

▲ Standard Slag Co. shipped 17,000 tons of iron ore from Nevada to Japan initiating a new ore movement.

▲ Pittsburgh Coke and Chemical Co. awarded Koppers Co. a contract to build an 850-ton blast furnace at Neville Island.

▲ According to the AISI, steel production beginning in July is scheduled at 100.8 per cent of capacity. This is equivalent to 2,015,000 tons compared with 2,055,000 tons one week ago.

July 3

▲ Dominion Steel and Coal Corp. is proceeding with the third phase of its modernization program at an estimated cost of $16,000,000. Work includes coke oven battery, two OH furnaces, and other facilities.

July 4

▲ Niagara Mohawk Power Corp. sold its coke producing facilities at Troy, N. Y. to Republic Steel Corp.

July 5

▲ According to a Senate sub-committee, tungsten supplies this year will be 2,000,000 lb short.

▲ Lake Superior Iron Ore Association reported iron ore shipments from the upper Lakes set a new rate for June with 13,166,130 gross tons.

▲ DPA awarded Kaiser Steel a 75 per cent tax write-off on a $55,000,000 plant to produce pig iron in Fontana, Calif.

July 6

Deputy Petroleum Administrator Brown predicted natural gas shortages next winter because of insufficient steel to complete pipe lines.

▲ NPA put slab zinc under complete allocation controls.

▲ Pittsburgh Coke and Chemical Co. plans to raise $4,000,000 through sales to stockholders of additional common shares at a ratio of 1 share to each 4 held.

▲ American Railway Car Institute reports that June production of freight cars totaled 9644. Orders in June totaled 6793 leaving a backlog on July 1 of 147,725.

July 7

▲ DPA announced that the demands for steel, copper and aluminum under CMP were 35 per cent in excess of supplies available.

July 9

▲ Based on reports of companies having 93 per cent capacity of the industry, the operating rate for the week beginning July 9 is 101.5 per cent of capacity. This is equivalent to 2,029,000 tons compared with 2,015,000 tons one week ago.

▲ The International Materials Conference set up world allocations of tungsten and molybdenum. U. S. gets largest share of both metals.

▲ API reports that oil industry will spend $3,000,000,000 for construction and $1,000,000,000 for replacement this year.

July 10

▲ Production of rolled steel products in West Germany totaled 807,177 tons in June compared with 744,045 tons in May.

July 11

▲ NPA is issuing an order which would further restrict the use of structural steel.

July 12

▲ International Materials Conference announced that sulphur allocations would go into effect immediately on a world wide basis.

July 13

▲ NPA is allocating steel for the freight car building program for the third quarter for production at a rate of 9500 cars a month.

▲ The first load of an ore shipping program from British Columbia to Japan starts this month. Ore is produced by Argonaut Co., Ltd.

▲ Wheeling Steel announced expenditures of an additional $24,000,000 for plant modernization within the next two years. The program will improve plant capacity and reduce cost.

▲ International Nickel announced that their production capacity is 21,000,000 lb per month.

▲ AISI announced that shipments in May totaled 1,231,000 tons to warehouses, 1,136,000 tons to the automotive industry, 104,000 tons to ordnance and direct military needs, 90,000 tons to shipbuilders, and 581,000 tons to rail transportation. Total steel shipments were 6,938,700 tons.

July 14

▲ F. W. Dodge Corp. announced record construction awards for the first half of 1951 of $8,808,109,000 in the 37 states east of the Rockies. Residential awards were down and non-residential awards were up.

July 15

▲ The New England Steel Development Corp. won a second four month extension on its certificate of necessity which covers the proposed New England steel plant.

▲ Republic Steel Corp. bought a 28-acre plot of land next to its Cleveland plant at a cost of $400,000. Land will be used for a coke plant and 1400-ton blast furnace.

July 16

▲ Bethlehem Steel received authorization for fast write off of 85 per cent of the $29,000,000 expansion program which the company is starting to increase coke and iron capacity.

▲ For the week beginning July 16th, steelmaking production is scheduled at 101.9 per cent of capacity. This is equivalent to 2,037,000 tons compared with 2,029,000 tons one week ago.

July 17

▲ Aluminum Association reports production in May totaled 135,440,954 lb, slightly above April.
▲ Universal Laboratories, Inc. is buying all properties of Ohio River Steel Corp. Ohio River Steel operates and owns mill at Toronto, Ohio formerly owned by Follansbee Steel.
▲ Wildcat strikes halted production at Roemer Works of Sharon Steel and Warren plant of Thomas Steel.

July 18

▲ Weirton Steel started construction of its new blast furnace at Weirton, W. Va.
▲ The Abbey Works at Port Talbot, Wales was opened officially. This new steel plant has a capacity of 2,000,000 tons annually which makes it the largest in Europe. Estimated cost was $168,000,000.
▲ Allegheny Ludlum Steel reported revenues for the second quarter totaled $58,748,747. Earnings totaled $2,923,590 after taxes or $1.80 per share. Revenues for the first six months totaled $116,666,494 and earnings were $6,227,281.

July 19

▲ A pilot plant will go into operation near Wilkes-Barre, Pa. to make cheap gas from anthracite waste.

July 20

▲ DPA stated that steel plate supply will not meet demand in the fourth quarter. About 2,500,000 tons will be available and the demand will be over 3,000,000 tons.

July 23

▲ Based on reports from companies having 93 per cent capacity of the industry, the operating rate for the week beginning July 23 is scheduled at 101.4 per cent of capacity. This is equivalent to 2,027,000 tons compared with 2,037,000 tons one week ago.

July 24

▲ The AISC reported June bookings of structural steel at 207,966 tons and shipments of 257,066 tons. Backlog for the next four months totaled 1,111,274 tons and the total backlog is 2,636,345 tons.

July 25

▲ Inland Steel reports net income for the first half of 1951 of $19,229,098 or $3.92 a share. This compares with $3.72 a share the first half of 1950. Sales for the first six months set a record of $265,936,760.
▲ W. Stuart-Symington stated that the RFC is considering another cut in the present price for tin of $1.06 a lb.
▲ United States Steel and United Steel Workers of America reached an agreement which provides additional insurance benefits to the employees. Blue Shield surgical benefits are being added to the present plan.

July 26

▲ Lukens Steel reported net income of $3,388,963 on sales of $54,160,808 for the first three-quarters ending July 7, 1951. This is equivalent to $10.66 a share compared with $2.33 a year ago.
▲ Price ceiling on copper refined from foreign ores was raised 3¢ to 27½¢ a lb. Domestic copper remains at 24½¢ a lb.
▲ ALCOA is building an $80,000,000 plant in Milam County, Texas, which will use lignite for fuel. Plant will have capacity of 170,000,000 lb of aluminum annually.
▲ Canadian Steel producers increased prices about $5.00 a ton.
▲ Acme Steel declared its 289th consecutive dividend since 1941 with a quarterly dividend of 50¢ a share.
▲ Koppers Co. purchased a 10 per cent interest in the Continuous Metalcast Corp.

July 27

▲ Ford Motor started a $43,000,000 expansion program at its Rouge Plant, which will increase finished steel output 190,000 tons. This is the second expansion since the end of the war.
▲ Bethlehem Steel Corp. reports total billings for the first six months were $876,141,692, total income was $164,162,542, and net profits were $48,694,975 or $4.74 a share compared with $5.63 a share for the same period last year.
▲ NPA put soft pig lead under allocation starting September 1.

July 28

▲ Alan Wood's 500-ton blast furnace was blown in today.

July 30

▲ Granite City Steel reported sales of $44,152,599 for the first six months of 1951, and net income of $3,039,106 or $2.38 a share. Both figures were higher than for the same period of 1950.
▲ Inland Steel Co. plans to offer all employees of the company, with at least two years service, options to buy stock.
▲ Armco Steel Corp. reported net earnings of $20,644,703 for the first six months of 1951 or $3.93 a share.
▲ Youngstown Sheet & Tube Co. reported revenues for the first half of 1951 of $245,534,280 and net income after taxes of $17,674,744.
▲ According to the AISI, steel production for the week beginning July 30 is scheduled at 101.5 per cent of capacity. This is equivalent to 2,029,000 tons compared with 2,027,000 tons one week ago.

July 31

▲ Jones & Laughlin Steel Corp. reported revenues for the first six months of $282,871,000 and net income of $17,134,000, equal to $1.37 a share.
▲ Sharon Steel started drilling a test gas well under the main works to see if it can augment its natural gas supply.
▲ United States Steel reports net earnings of $106,797,497 on gross revenues of $1,725,601,263 for the six months ending June 30, equal to $3.61 a share compared with $4.08 a share one year ago.
▲ Republic Steel Corp. reports net profits of $26,729,493 on revenues of $531,843,925 for the first six months of 1951. This is equivalent to $4.39 a share after preferred dividends compared with $6.25 one year ago.
▲ National Steel Corp. reports net income for the first six months of 1951 of $27,293,227 or $3.71 a share compared with $3.94 a share for the same period of 1950.

Heavy Duty Safety Switch, and Circuit Breaker

RAIN-TIGHT! DUST-TIGHT!

RAIN-TIGHT SAFETY SWITCHES with receptacle, fusible or fuseless, ratings up to 100 amps, 600 volts . . . without receptacle, up to 200 amps, 600 volts. (NEMA TYPES V, IV and III)

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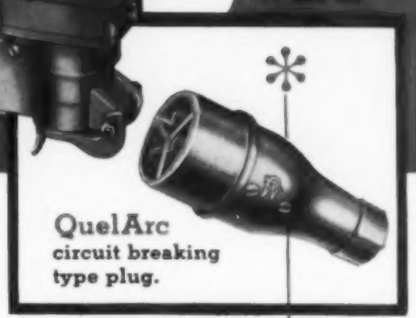
PYLETS



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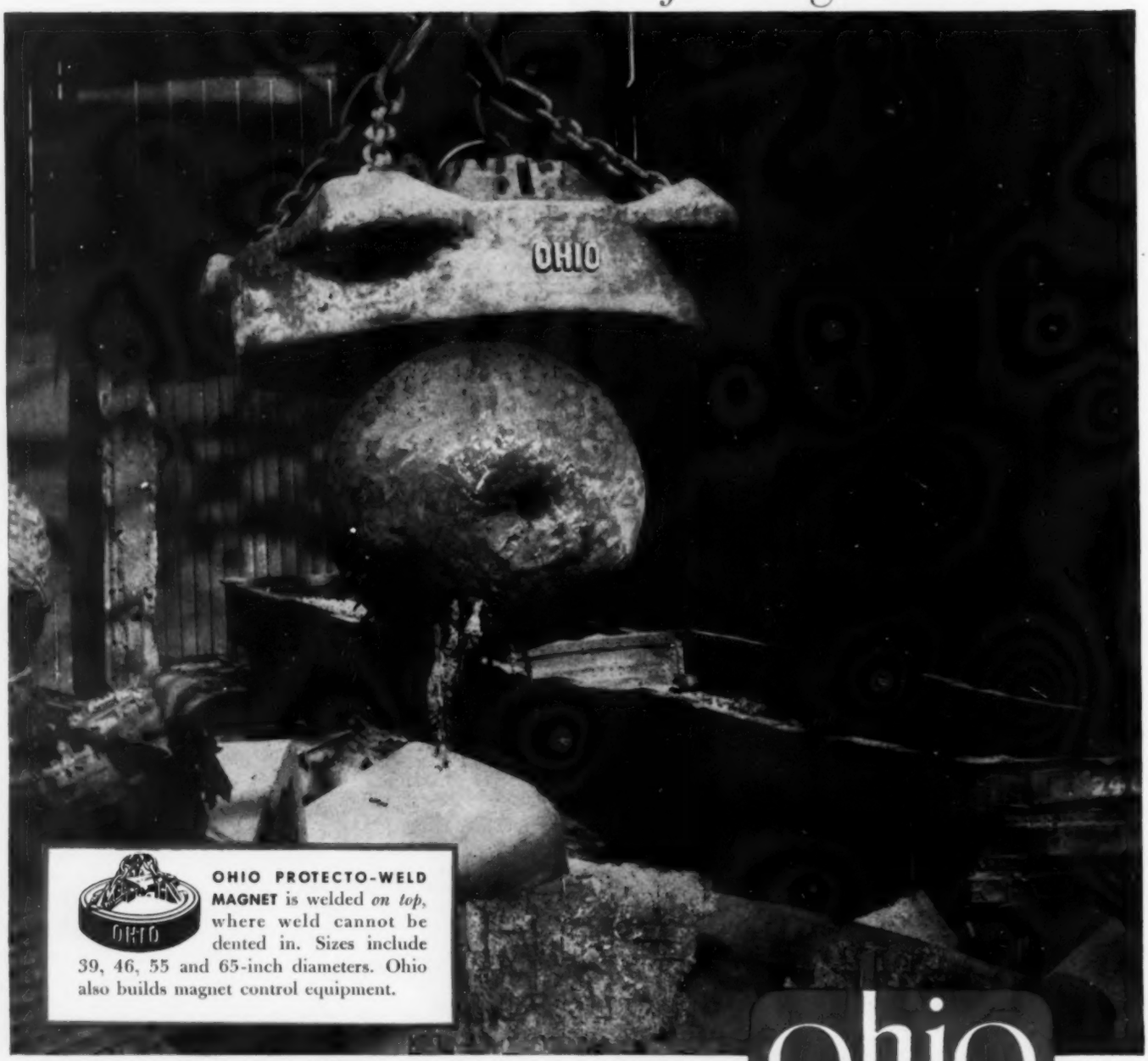

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Industry News...

WEIRTON STEEL BREAKS GROUND FOR NEW BLAST FURNACE CONSTRUCTION

▲ Ground has been broken for construction of a new blast furnace with an annual capacity of 480,000 tons at the plant of the Weirton Steel Co., Weirton, W. Va.

National Steel now has two giant blast furnaces under construction. The other furnace is being built at the plant of Great Lakes Steel Corp., another subsidiary company in Detroit, Mich. The Great Lakes furnace also will have a capacity of 480,000 tons of pig iron per year and is scheduled for completion early in 1952. The Weirton furnace is expected to be placed in operation later in the same year.

The two furnaces are major components of National's current $150,000,000 expansion program which will increase the company's ingot capacity to a total of 6,000,000 tons by 1953, compared with an ingot capacity of 4,750,000 tons as of January 1, 1951. This increase will result entirely from the expansion of facilities at Weirton and Great Lakes and, therefore, does not include any tonnage for a new steel mill to be built in the future by National Steel Corp. on a recently acquired site near Camden, N. J.

The new Weirton furnace will have a hearth diameter of 25 ft, 6 in. and a height of 162 ft from ground level to the top of the bleeder valve. Each of the furnace's three stoves will be 110 ft in height and 26 ft in diameter. All auxiliary facilities will be of the most modern design.

Weirton Steel's present blast furnace plant consists of three large furnaces. The new furnace, with auxiliary facilities, will occupy a 9-acre tract of ground adjacent to the present plant. To make this space available, the city of Wierton vacated parts of three streets and five alleys, and the Weirton Steel Co. purchased more than 100 privately-owned buildings. Most of these buildings were dwellings which were built shortly after construction of the first plant at Weirton in 1910.

Weirton Steel helped many of the families who sold their homes to relocate in newer residential sections of the city.

NEW ORE DOCK RECEIVES LIBERIAN ORE

Bearing iron ore from Liberia, the SS Simeon G. Reed is unloaded at the new $5,000,000 ore unloading dock of the Baltimore & Ohio Railroad, Baltimore, Md. The ore is consigned to plants of Republic Steel Corp. in northeastern Ohio. Tonnage from later shipments will be sent to these and other Republic plants in Chicago, Buffalo and Gadsden. Mining operations of the high-grade Liberian deposits have just been started by the Liberia Mining Co., Ltd., a Liberian concern in which Republic Steel is owner of a substantial share. Assaying at nearly 70 per cent iron the deposit is among the richest in the world.

TWO GIANT OREBOATS NOW BEING BUILT

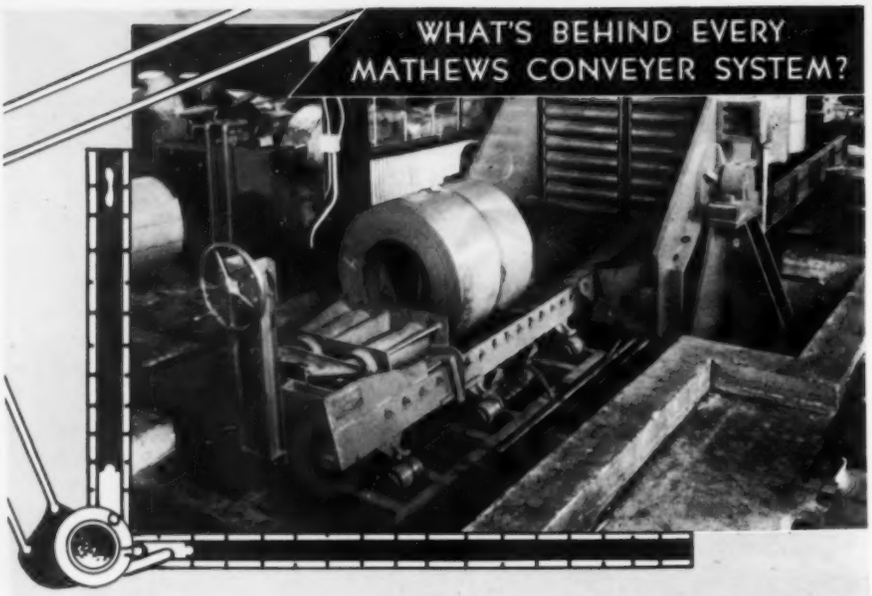
▲ A major step in the construction progress of the two new giant ore boats being built for Pittsburgh Steamship Co. at Lorain, Ohio, was reported. Stern frames — two towering pieces of steel framework each weighing 96,000 lb — have been set in position at the Lorain yards of American Shipbuilding Co.

A similar point in construction progress will be reached shortly at the Detroit yards of Great Lakes Engineering Works, where the third of three new 647-ft boats is being built for addition to the Pittsburgh Steamship fleet of 61 vessels. All are scheduled for launching this fall and for delivery in time to start hauling ore from upper lake ports to furnaces at lower lake ports at the start of the 1952 shipping season.

In addition to the three ore carriers, a giant new limestone carrier — a 666-ft self-unloader, is being built at Manitowoc, Wisc., for the Bradley Transportation Co., another U. S. Steel subsidiary.

The hull structure of the first boat being built at Lorain, for which the keel was laid on December 18, 1950, is approximately 65 per cent completed. The other two hulls, on which work started some weeks later, are 50 and 45 per cent completed respectively.

The stern frames are one-piece steel sections which serve as the framework for the propeller and rudder. Each of



A skilled production force

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CANADIAN DIVISION . . . . . *Mathews Conveyer Company, Ltd.*
PORT HOPE, ONTARIO

the 48-ton pieces was cast in five sections by the Penn Steel Castings Co. The individual pieces then were moved to the yards, where they were welded and machined to rigid specifications to form a single unit for each boat.

Erecting the huge pieces, nearly 28 ft high and 25 ft from front to back, represented a difficult engineering operation. A 75-ft gin pole was set up to hoist each frame into its predetermined position at the stern end of each of the ways. The actual lifting took only a matter of minutes but hours were required for the intricate business of fitting the frames into place. Despite the size of the frames, shipyard crews were working against tolerances of one-sixteenth of an inch.

SHEET AND TUBE BUYS SLAB HEATING FURNACE

▲ Youngstown Sheet and Tube Co. has awarded Salem Engineering division of Salem-Brosius, Inc., a contract for design and erection of a triple-fired pusher type slab heating furnace at the company's Indiana Harbor, Ind., works.

The furnace, which will heat steel slabs from room temperature to 2300 F at the rate of 80 tons per hour, will be complete with Salem's needle type metallic recuperator. The production capacity is based upon heating slabs 7 in. thick × 30 in. wide × 15 ft-6 in. long.

Erection is scheduled to get under way in the first quarter of 1952.

WEST COAST GETS STEEL PICKLING PLANT

▲ A new job steel pickling plant, Rich Steel Pickling Co., Los Angeles, Calif., believed one of the most modern on the Pacific Coast, has recently been completed and is now in operation.

The new plant is said to be capable of handling steel in sizes up to 30 ft long and 6 ft wide. Steel sheets, plates, coils, bars, pipes, structural shapes, stampings and a variety of other forms can be pickled, either dry or oiled. An outstanding feature of the new plant is its method of applying a new "phosphate-protected" coating, to all steel processed.

Construction of the new plant was motivated by the critical shortage of many types of steel during the present

3 REASONS WHY

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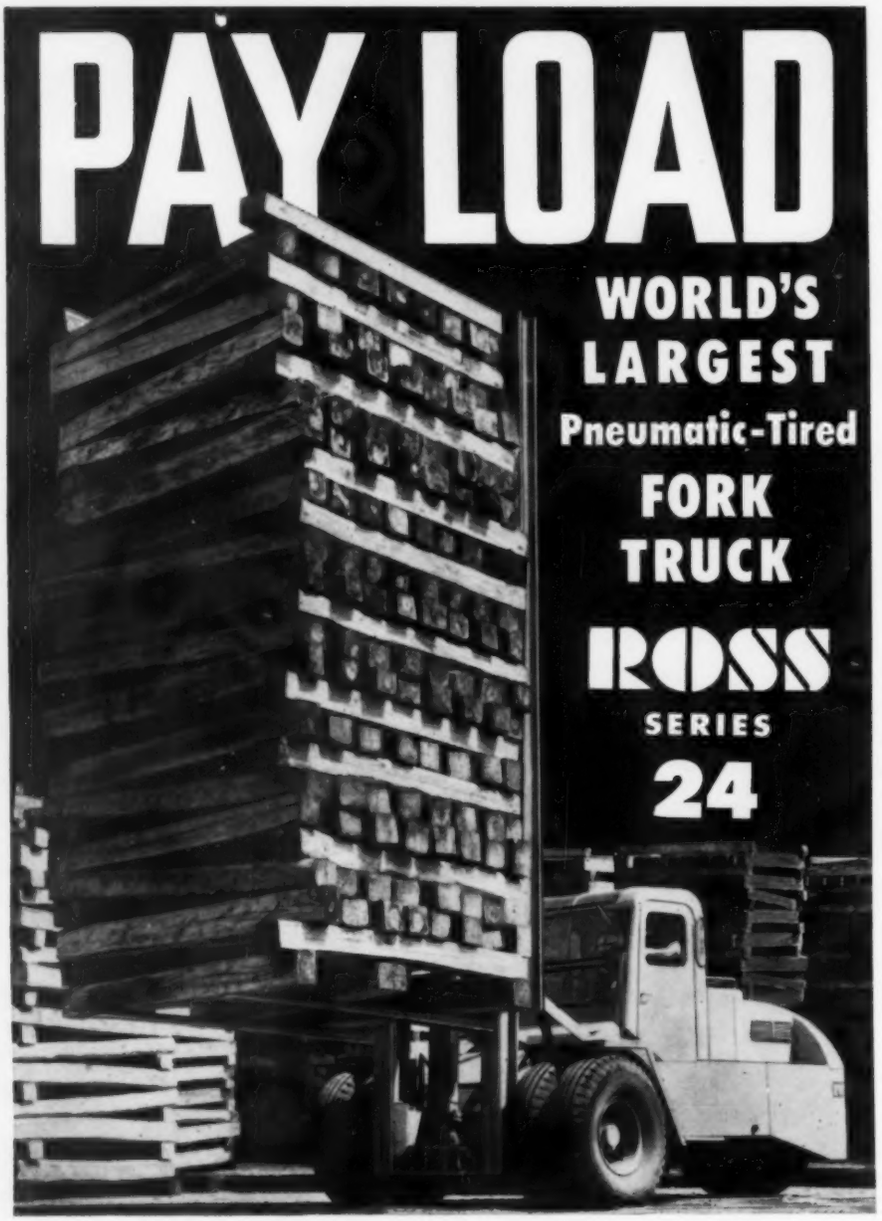

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COKE & CHEMICAL FIRM MAKES FINE CHEMICALS

▲ Pittsburgh Coke & Chemical Co. has announced the formation of a new fine chemicals division which will manufacture and sell a number of synthetic organic chemicals. Production facilities now under construction, are located on Neville Island near Pittsburgh, Pa. Initial operations will concentrate on the manufacture of certain dyestuffs. It is expected that units of the new division will be in production before the end of the year.

ARMCO BEGINS BUTLER CONSTRUCTION PROJECT

▲ Construction has begun on a $2,000,000 project to increase the production of electrical steel at the Butler, Pa., division of Armco Steel Corp.

A battery of new annealing furnaces is being constructed, and equipment is being added to process this special type of steel. In addition, new shears are being installed and the shipping facilities of the plant are being increased.

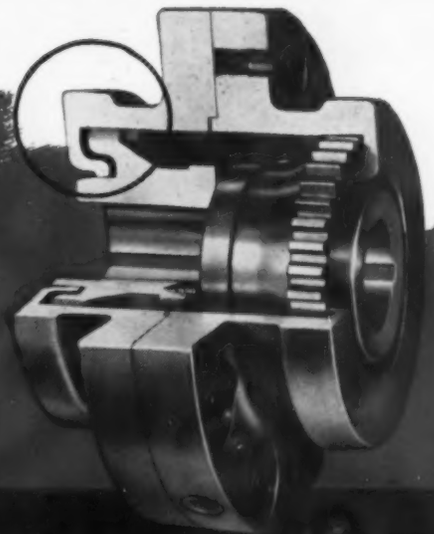
SHARON STEEL DRILLS FOR GAS UNDER PLANT

▲ Work has been started on a gas drilling operation by Sharon Steel Corp. adjoining the company's Roemer works at Farrell, Pa. Actual operations started over the week end, with drilling in this well tentatively scheduled to go down to 3800 ft.

Following extensive work by geologists, the company has been advised that there are three possible gas producing horizons under Sharon Steel's main works. There have been no wells drilled in the immediate area to disprove the possibility of success. Sharon is conducting the test to search for possible reserve fuel sources to augment existing piped in natural gas and fuel oil.

Drilling is taking place near the Ohio state line in Hickory Township, Mercer County, on the farm of Charles Cromartie, on the Walker Road, west

NEED "SPECIAL" COUPLINGS?



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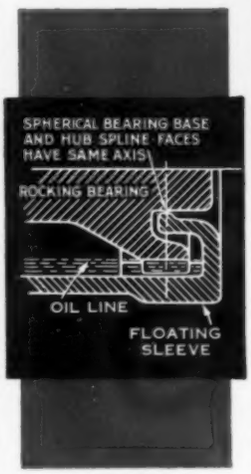
STANDARD Fast's Couplings



FOOLPROOF DESIGN: Instead of perishable oil seals, Fast's use a permanent metal-to-metal closure. Oil is always maintained at a safe level, whether the Fast's is running or standing still!

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NEW DEVELOPMENTS: Fast's were the first gear-type couplings on the market. And they're first again with new designs developed by Koppers —like the revolutionary new Breaking Pin Coupling now available.

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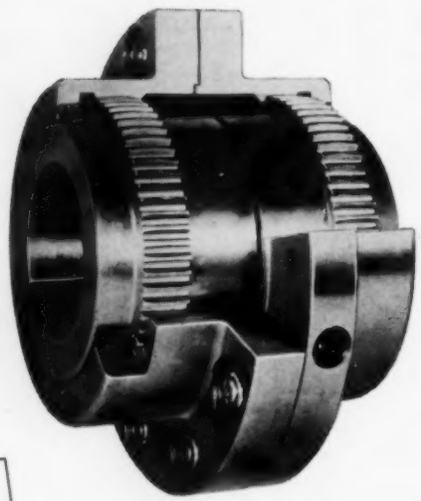

LARGER BORE

New WALDRON design affords a larger maximum bore to permit use of larger shafting, smaller physical capacity for same size shaft with reduced rotating weight.

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WALDRON cover sleeve is one solid forged steel unit. With *no welded parts* the accurate gear in sleeve cannot become distorted. Added assurance of safety at high speeds.

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WALDRON oil and dust seal, impervious to mineral lubricants, hermetically seals against oil oxidation. Ever present oil film carries load with no possibility of wear from metal-to-metal contact.

MOST ECONOMICAL

Their past performance records coupled with new design and construction features combine to prove WALDRON Couplings the most economical to buy as well as use for longer service life.

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of the town of Wheatland. It is estimated that it will take approximately 60 days for this well to be drilled. Nearest known commercially producing gas wells are 15 miles north of Sharon, also near the state line.

It has been approximately 30 years since the operation of a shallow oil and gas field in the Sharon area. These wells, drilled to 700 ft, have long since been abandoned.

PRESSED STEEL CAR ACQUIRES TANK FIRM

▲ Pressed Steel Car Co. announced that it had acquired the 53-year-old Chicago Steel Tank Co. The latest acquisition brings to five the number of steel fabricating companies that Pressed Steel Car Co. has acquired since its product diversification program began fifteen months ago.

The Chicago Steel Tank Co. acquisition includes two subsidiary companies, Steel Erectors, Inc., which operates as a field installation arm of the parent company, and Conduit Fittings Corp., makers of parts for electrical appliances and systems. The company and both of its subsidiaries occupy a large plant in South Chicago's Clearing District.

WESTINGHOUSE SUPPLIES ALUMINUM CO. PLANT

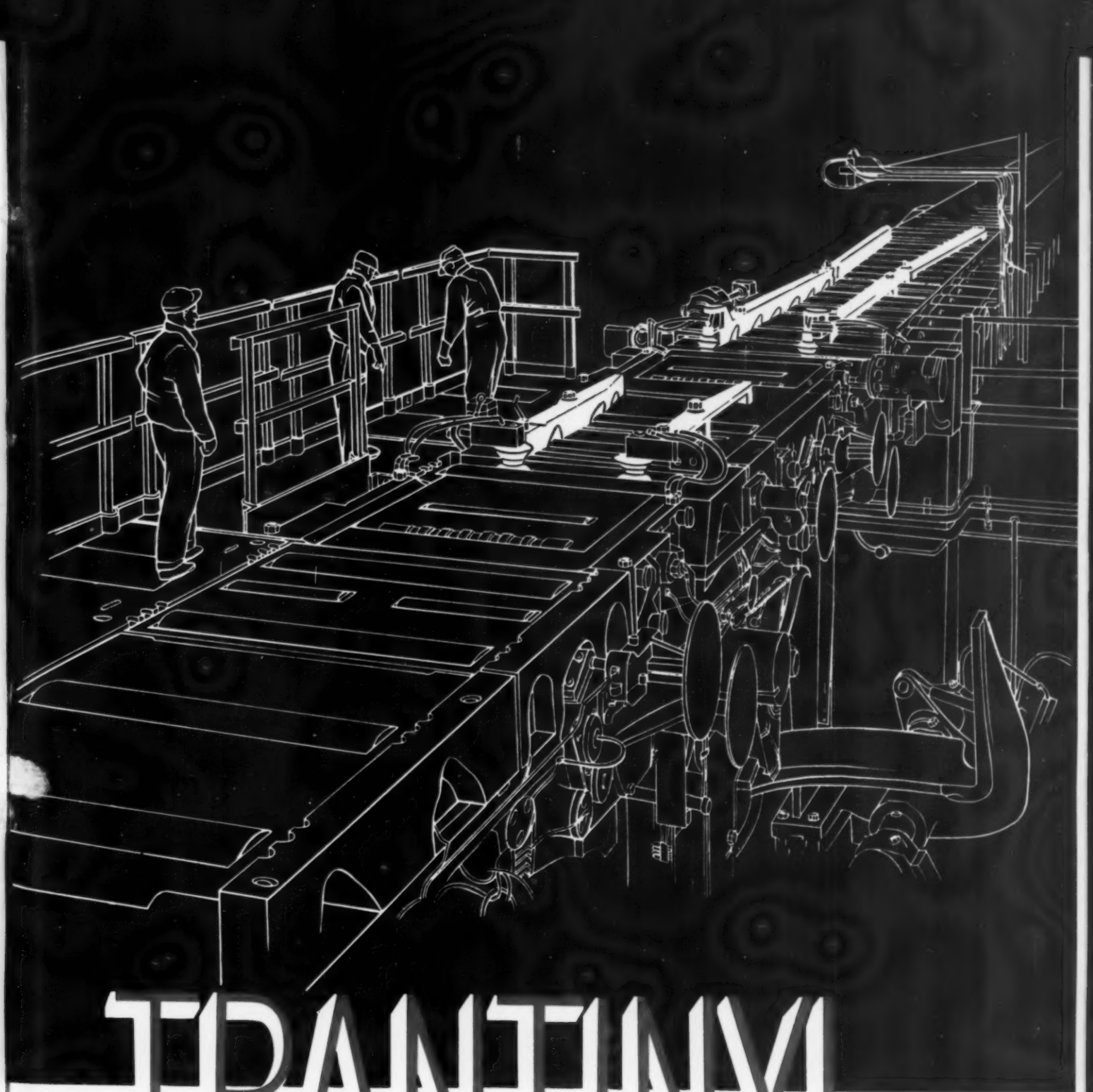
▲ Westinghouse Electric Corp. will supply over three million dollars worth of electrical equipment for the new aluminum reduction plant being erected at Wenatchee, Wash., by the Aluminum Co. of America.

The contract provides for 24 ignitron rectifier units as well as transformers and other auxiliary equipment. This equipment is scheduled for delivery to the Washington site early next year.

The new 50 million dollar plant will be capable of producing some 170,000,000 lb of aluminum annually.

ENGINEERING FIRM OPENS PITTSBURGH OFFICE

▲ Pittsburgh Professional Engineering Service announces the opening of their new office in the Law & Finance Building, Pittsburgh 19, Pa. The company will engage in general engineering and heavy machine design under the direction of Emil Ehret.



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THE STEEL INDUSTRY

Wear-Resistant Tools for the Rolling Mill Industry

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REPUBLIC STEEL BUYS BILLET HEATING FURNACE

▲ Republic Steel Corp. has awarded a contract to George J. Hagan Co., for a rotary hearth billet heating furnace for the new seamless mill at South Chicago, Ill.

The furnace will be equipped with automatic charging and unloading equipment, as well as automatic furnace pressure control, automatic combustion control and automatic temperature control, to provide a completely automatic installation from billet storage table to piercer inlet.

IRVIN WORKS BUILDING PICKLING WASTE UNIT

▲ New facilities which will neutralize waste pickle liquor faster and more efficiently are under construction at U. S. Steel Co.'s Irvin works, Dravosburg, Pa., by Rust Engineering Co.

Daily processing capacity of the new system will be about 100,000 gal of pickle liquor — a waste solution from pickling acids in which strip steel is immersed for cleansing.

The project includes a control house with laboratory, and push-button facilities for operational control of the entire system. Besides processing, storage, and materials handling equipment, two new rail sidings will be built to facilitate time loading and sludge removal.

COLUMBIA STEEL ADDS NEW TRAMWAY DIVISION

▲ Establishment of a tramway division by Columbia Steel Co. was announced. Columbia Steel's tramway division is the only one of its kind in the United States Steel organization, and is in a position to bid all jobs completely erected as a prime contractor for projects located anywhere in the United States. It was pointed out foreign projects will be bid through the U. S. Steel Export Co.

The tramway division was attached originally to the Trenton Iron Co., and subsequently to the U. S. Steel subsidiary, American Steel and Wire Co. It has built approximately 800 tramways, cableways, and bridge jobs.

AUSTRIAN MILL IS MOST MODERN IN EUROPE

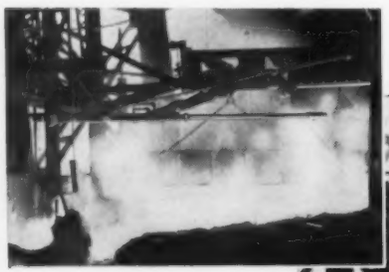
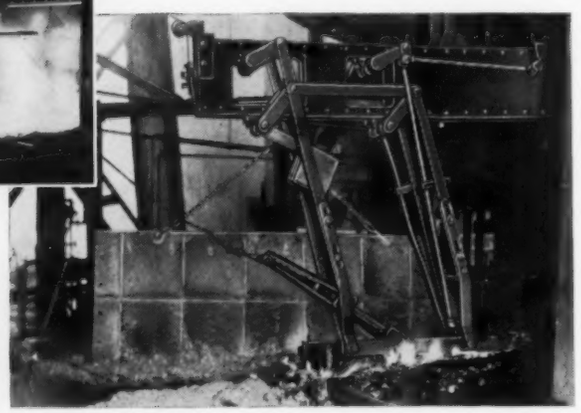
▲ A new $7,380,000 steel blooming mill has made the Oesterreichisch-Alpine Montangesellschaft steel works in Donawitz, Austria, one of the most modern in Europe.

Located in the American zone of occupation within 50 miles of the Iron Curtain, the mill replaces one dismantled by the Russions in 1945 as war booty. The new facility was financed by ECA funds.

Scheduled to furnish 60 per cent of Austria's crude steel, the mill is equipped throughout with General Electric drives, controls and switchgear.

The mill is designed for a capacity of 75,000 tons of steel monthly. It was fabricated and equipped by Morgan Engineering Co. of Alliance, Ohio; International General Electric Co. and Loewy Rolling Mill Division, Hydropress, Inc.

Situated in the scenic Mur Valley in the Austrian Alps, the new mill uses $1,500,000 of G-E equipment. Principal items are an 8000-hp main

The Bailey

CINDER NOTCH STOPPER

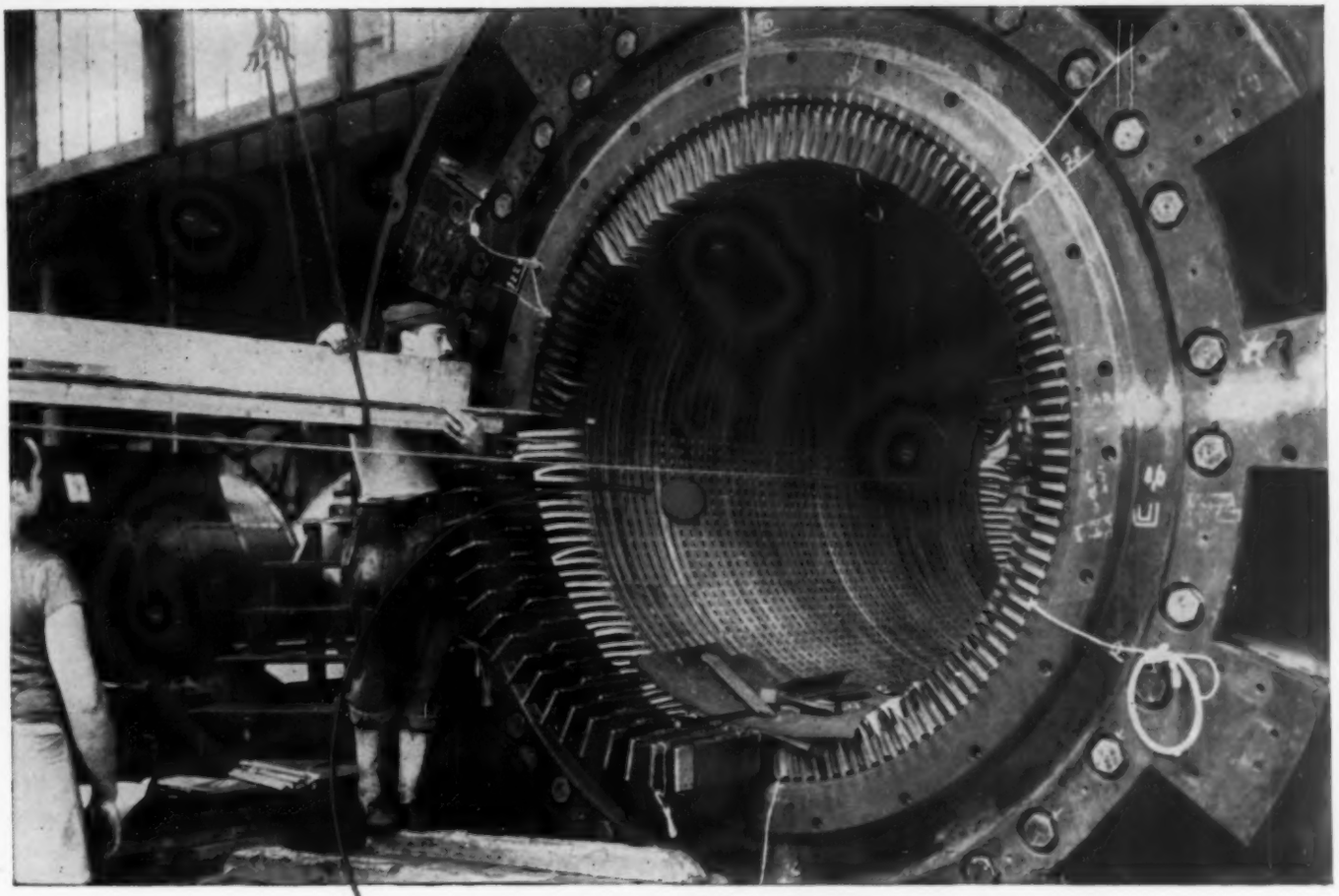
for Safe, SURE CLOSING

- Absolute safety while inserting or withdrawing
- Adaptable to any cinder notch
- Same mechanism inserts and removes botter
- True alignment with cinder notch at all times
- Water-cooled cinder bott and rod
- Botter rod when withdrawn is well above trough

No workman need enter the danger zone to close blast furnace cinder notches, since all controls of this service-proved device are located in a remote position. Using a unique gravity action for inserting the bott in the monkey, it employs air or steam power action only for withdrawal.

In operation, an air or steam powered cylinder withdraws stopper to the "out" position, with a latch locking the bott rod in position during the flush. A tag line is used to release the latch, with gravity action immediately inserting the bott in the monkey. For over 20 years the Bailey Cinder Notch Stopper has been known for dependability and safety throughout the steel industry.

WILLIAM M. Bailey COMPANY
ENGINEERS
LEADERSHIP THROUGH QUALITY
1221 BANKSVILLE ROAD PITTSBURGH 16, PA.



National gave this generator brand-new power

In the illustration at the top of the page the coil bars are being drawn into position. The lower illustration shows the coils being connected to the leads. This 3-phase, 50-cycle, 13,800-volt generator develops 45,000-kva at 1500-rpm.

Extra flexibility was needed in this rebuilding job. When the generator failed it was necessary to find someone who was equipped to handle the specialized repairs which were required. National was chosen. National engineers and technicians completely redesigned the stator windings; the National shops produced the bar design low-loss Roebel transposition type coils; and a National engineer was right there on the ground to supervise the actual rewinding of the generator. The result? A stator which gives more power at a lower operating temperature.

National can do the same for *your* motors or generators, whether they are special or not. Our experience and equipment are ready to work for you and to lower your power costs. Write or wire (or cable NATCOIL) *today*.

NATIONAL ELECTRIC COIL COMPANY

COLUMBUS 16, OHIO, U. S. A.

ELECTRICAL ENGINEERS: MAKERS OF ELECTRICAL COILS AND INSULATION—REDESIGNING AND REPAIRING OF ROTATING ELECTRICAL MACHINES

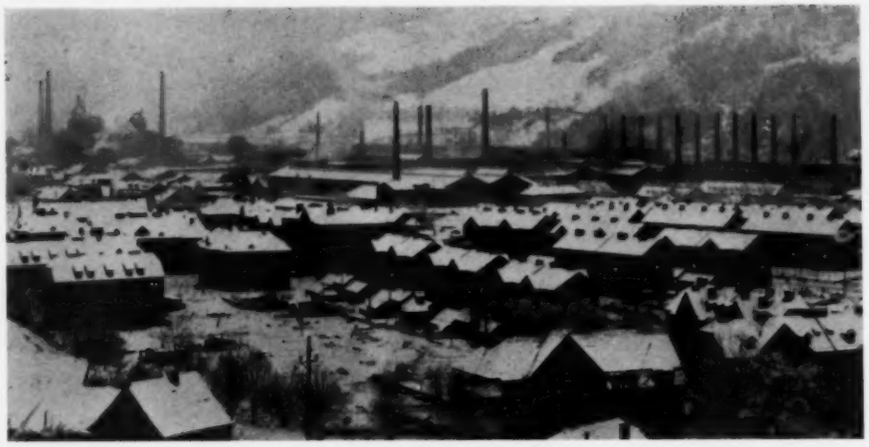
FRAME MARK

drive and a flywheel motor-generator set.

The twin mill drive uses two 4000-hp, d-c motors operating on 800 volts. These single armature, reversing motors produce 8000 horsepower at 50 rpm with a maximum of 120 rpm and a peak load capacity of 275 per cent. The motors can be reversed at the 50-rpm level in less than two seconds.

Supplying power to the motors is a flywheel motor-generator set which includes a 6000-hp, 500-rpm wound rotor induction motor, four 1750-kv, d-c generators and a steel plate flywheel with a stored energy of 185,000 hp-seconds at 500 rpm.

General Electric also supplied the mill's auxiliary drive equipment, controls, 6000-volt metal clad switchgear and ventilating equipment.



Located in the scenic Mur Valley in the American occupation zone of the Austrian Alps, the Alpine-Montan Steel works is being expanded and modernized under a Marshall Plan grant.

Officials of the Austrian firm hope for a production of nearly a million tons of steel annually within the next three or four years. The maximum output of the old mill was less than half of this figure.

G-E currently is supplying principal electrical equipment for a billet and sheet bar mill now nearing completion at the Donawitz works, and will provide roughly $500,000 in equipment for a rail and structural mill to be built there.

SAVE ACID WITH Rodine®

PICKLING ACID INHIBITORS

Pioneering Research and Development Since 1914

AMERICAN CHEMICAL PAINT COMPANY

AMBLER, PA.

Manufacturers of METALLURGICAL, AGRICULTURAL and PHARMACEUTICAL CHEMICALS

YODER BUILDS TUBE MILL FOR LONE STAR STEEL

▲ Yoder Co., Cleveland, Ohio, is building for the Lone Star Steel Co., Dallas, Tex., an electric resistance-weld tube mill with a capacity for making line pipe and casing in sizes from 4½ in. up to 16 in. outside diameter, in thicknesses ranging up to 9/16 in.

The mill will handle either piled skelp or coiled strip, and will have a welder of unusually high capacity — one of the largest of its kind ever built.

The units for stock preparation include a leveller, a slitter for edge trimming, a scrap chopper, and a shot blast machine for marginal cleaning, with necessary pinch roll stands and conveyors for moving the skelp through the various units to the pipe forming machine.

Incorporated in the mill will also be equipment for thermal and physical processing by means of which high physical properties will be obtained.

This will be the third complete electric resistance weld tube mill built by Yoder since World War II for making pipe and tubing up to 14 in. diameter and larger.

The first of these were built for the Page-Hersey Co. of Welland, Ont., equipped with a 1600-kva welder, for

HOT BILLETS go for a COOLING RIDE

Designed and built for getting maximum production from steel mill operations, this mammoth cooling bed handles tremendous tonnages and a wide variety of semi-finished products.

The first section of the bed consists of V-bars which present either notched or flat surfaces—depending upon the type of product handled. These bars are accurately machined to hold billets straight during the cooling period. The flat bar section, following the first section, increases the capacity by providing additional cooling time for heavy sections.

Cooling beds such as this comprise but part of the complete line of steel mill machinery—rolling and blooming mills, rolls, shears, straightening machines, flange spinning machines and others—produced by Birdsboro. Bring your problems to Birdsboro engineers who offer a specialized service in designing and building machines to perform many "run-of-mill" and special steel mill operations.

BIRDSBORO

STEEL FOUNDRY & MACHINE CO.

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STEEL MILL MACHINERY

Designers and Builders of:

Steel Mill Machinery • Crushing Machinery • Rolls

Hydraulic Presses • Special Machinery • Steel Castings

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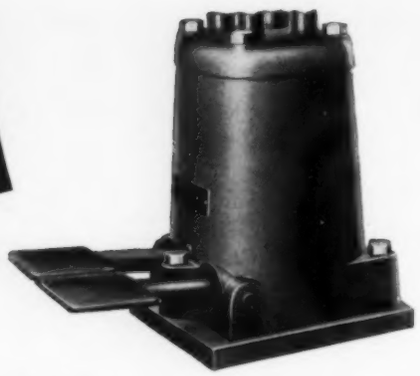
Offices in:

Birdsboro, Pa., and Pittsburgh, Pa.

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

No. 3401-R-4
½ Inch 4-Way
Foot Valve



FOOT OPERATED Air Valves

Increase output of hammers, shears, presses, etc.

● Operators have both hands free to handle the work—speeding production. Valving mechanism has stainless steel body and push-pull rods, brass sleeves, self-sealing U-packers and many other refinements, all fully enclosed against dirt, assuring long efficient trouble-free operation. Convenient pipe connections. No metal to metal seating. ⅜" to 1" sizes, 3-way and 4-way, neutral position and regular actions. *Write for full details.*

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

Mfd. by C. B. HUNT & SON, INC., 1987 East Pershing St., Salem, Ohio

EF

GAS-FIRED
OIL-FIRED
and ELECTRIC
FURNACES
for

AGING
ANNEALING
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CARBON RESTORATION
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CERAMIC DECORATING
DRAWING
HARDENING
HOMOGENIZING
MALLEABLIZING
NORMALIZING
NITRIDING
SINTERING
SOLUTION TREATING
SPECIAL ATMOSPHERE TREATMENTS

BRIGHT ANNEALING AND NORMALIZING STEEL STRIP *Continuously*

● EF continuous annealing and normalizing furnaces subject the entire length of the coil to exactly the same time and temperature cycle, producing extreme uniformity of grain size, resulting in superior qualities for deep drawing.

These furnaces shorten the annealing and normalizing cycle – and reduce the tonnage of material in process. Tension on the strip, the speed of travel and the atmosphere in the furnace are accurately controlled, producing the exactly desired surface finish and physicals – day after day. Capacities to meet any requirement.

A SIZE AND TYPE OF FURNACE FOR EVERY PROCESS PRODUCT OR PRODUCTION

THE ELECTRIC FURNACE CO.
GAS FIRED, OIL FIRED AND ELECTRIC FURNACES
Salem - Ohio

making pipe up to 16-in. diameter, ½ in. thick. The second was built for Kaiser Steel Corp., Fontana, Calif., having a 2000-kva welder with capacity up to 14-in. diameter and ⅜-in. thickness. In addition, a 1500-kva welder was built for the press-forming tube mill of the Basalt Rock Co., Napa, Calif., for making pipe up to 20-in. diameter.

Including the Lone Star mill, there will be a total of six large resistance-weld continuous mills in operation in the USA and Canada, five will have been built wholly or partly by Yoder. Of smaller mills, the Yoder Co. has built a total of about 150. Nearly one-third of these have been installed in foreign countries.

WHEELING STEEL CORP. TO SPEND $24,000,000

▲ A new $24,000,000 construction and improvements program, designed to boost steel production capacity for the Wheeling Steel Corp., will bring total costs of post-war expansion to more than $100,000,000, it was announced by John L. Neudoerfer, president of Wheeling Steel Corp.

Under construction now is a battery of 63 by-product coke ovens to cost about $9 billion which will give Wheeling a total of 314 ovens with auxiliary by-product facilities. These will make Wheeling self-sufficient, as far as coke is concerned, resulting in a substantial cost reduction based on capacity production of steel and steel products.

By the end of 1953, Wheeling Steel will spend an additional $24 million on its manufacturing plants, principally to increase capacity and lower costs in line with the national effort to raise steel production substantially. This part of the program will include modernization of cold reduced sheet facilities, reconditioning two bessemer converters, improved materials handling, and additional annealing capacity at Steubenville; installation of a new continuous galvanizing line at Martins Ferry; mine mechanization and a new coal washing plant at the Harmarville, Pa., mine.

METAL CASTING MACHINES TO BE SOLD BY KOPPERS

▲ Engineering, fabrication, erection and sale of continuous casting machines licensed by Continuous Metal-

cast Co., Inc., in the future will be performed by the Freyn Engineering department of Koppers Co., Inc.

This was disclosed following a joint announcement by General Brehon Somervell, chairman and president of Koppers, and H. G. Batcheller, chairman of Continuous Metalcast who also is chairman of Allegheny-Ludlum Steel Corp., that an interest in Continuous Metalcast has been sold to Koppers.

GARY ANNEALING LINE PLACED IN OPERATION

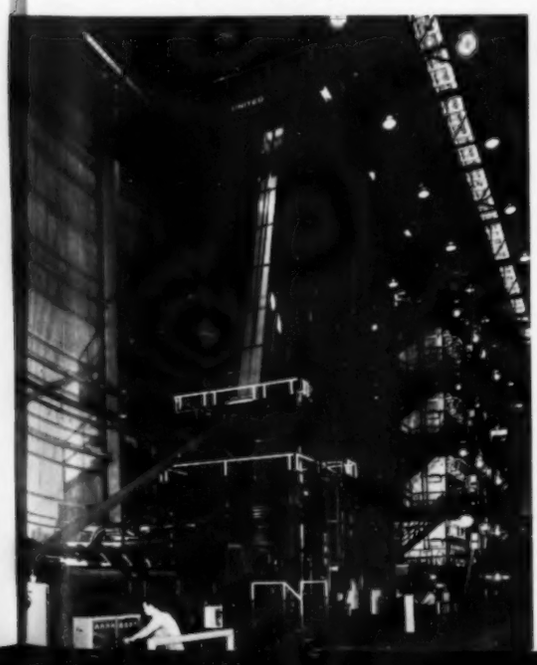
▲ A new continuous annealing line has been placed into operation at the tin mill division of United States Steel Co.'s Gary, Ind., sheet and tin mill. The line makes possible continuous annealing of steel for tin and blank plate products in varying thicknesses, 18 to 37 in. wide, at a speed of approximately 1000 fpm.

Construction of the line, which has an annual capacity of about 136,000 tons, was started almost a year ago. It is housed in a new building 336 ft long and with a ceiling height of 76 ft. The furnace section equipped with combination gas and electric heating units, is approximately 64 ft above the plant floor level.

After cold reduction, tin plate is stiff and unyielding. To give it the pliability necessary for forming into cans, the material must be annealed.

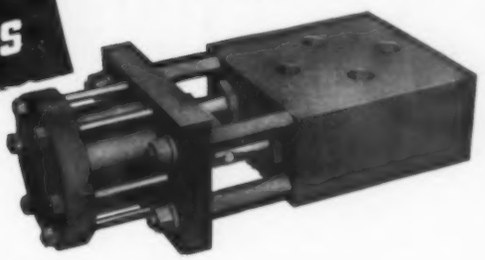
This installation is part of the overall program initiated by United States Steel last year to increase the productive capacity of the Gary Sheet and tin mill.

The line enables continuous annealing of tin and black plate products at the rate of 1000 fpm.



Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

¾ Inch 4-Way — 5000 p.s.i.
Piloted Hydraulic Valve



PILOT OPERATED Hydraulic Valve
For hydraulic systems to 5000 p.s.i.

● Designed for controlling double acting hydraulic cylinders. The pilot cylinder is controlled by any type of 4-way air valve and is operated either automatically or manually from a convenient control station. Machined steel housing, hard chrome plated ground and polished stainless steel plungers, molded packers sealed by valve pressure. All parts readily accessible without disturbing the piping. ½" to 4" sizes. *Write for full details.*

THE HIGHER THE PRESSURE THE TIGHTER THE SEAL

Quick-As-Wink
AIR AND HYDRAULIC
Control Valves

Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated
Mfd. by C. B. HUNT & SON, INC., 1984 East Pershing St., Salem, Ohio

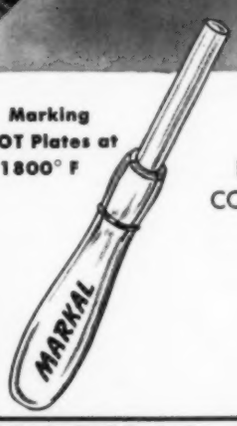
"15 Cents - - Saved us $15,000"

Says Steel Man

"Poor identification made with an inferior crayon burned off. In error, a soft iron slab went through the rolls which were set for a high carbon slab, causing a cobble and ruining the rolls, with a big loss of time. MARKAL PAINTSTIKS stopped this waste of money, time and production"

MARKAL PAINTSTIKS

Marking HOT Plates at 1800° F



are PERMANENT - *Weatherproof, Fadeproof*

Proved performance for HOT CASTINGS • STICKERS
COILS • PLATES • FORGINGS • ANNEALING • WELDING

Don't be misled! There's only one
MARKAL PAINTSTIK — *the Original!*

Write for FREE SAMPLE. We'll gladly help with any marking problem. Ask us.

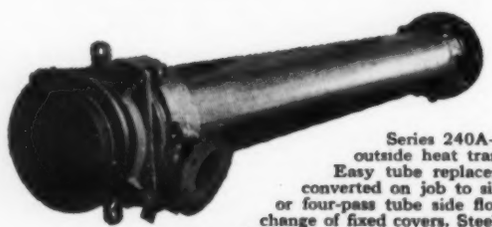
MARKAL CO. 3087 W. Carroll Ave., • Chicago 12, Ill.
"Originators of Paintstiks"

"KARBATE" BRAND IMPERVIOUS GRAPHITE HEAT EXCHANGERS *FOR ALL PURPOSES!*

The "Karbate" impervious graphite heat exchangers illustrated are used extensively as boilers, coolers, condensers, vaporizers, evaporators, heaters and absorbers in handling corrosive chemicals, either hot or cold. They *all* can be had in a complete size range. *All of them* offer the following advantages:

- **Highest heat conductivity rate of the practical corrosion-resistant materials.**
- **Highly resistant to corrosion by acids or alkalis, hot or cold.**
- **Freedom from corrosion scale, as compared to metals.**
- **Immune to thermal shock.**
- **No contamination of product.**
- **Strong and easy to install and maintain.**

Shell-and-Tube: Series 70A—Two sizes, 16.4 sq. ft., and 24.6 sq. ft. of outside surface area respectively. Tubes easily replaced in the field. Interchangeable single and double-pass construction.



Series 240A—70.6 feet of outside heat transfer surface. Easy tube replacement. Easily converted on job to single, double, or four-pass tube side flow by simple change of fixed covers. Steel, shell, oversize shell connections, impingement plates and drain and vent plugs integral with shell end castings. Stainless-steel baffles assembled with steel tie rods to form protective cage for tube bundle. Removable "Karbate" tube bundle. Write for catalog sections for S-6690, S-6715 for details of applications, maintenance, sizes and characteristics of these exchangers.

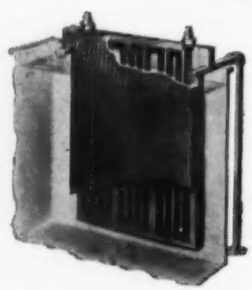
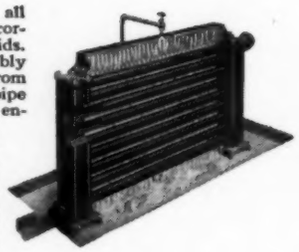
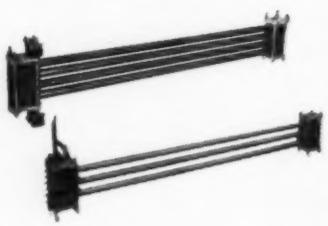


Plate heaters: Used to heat or cool corrosive liquids in tanks and vessels. Compact, completely assembled, easy to put in. Used in pickling, etching, plating and cleaning tanks. Complete size range. Models for horizontal and vertical mounting. Write for catalog section S-6620.

Style FH heat exchangers (Size 1½): Are especially recommended for tanks with solution depths of 16 inches or less. Write for catalog section S-6750.

Cascade coolers: For all cooling jobs involving corrosive gases and liquids. Complete cooler assembly may be made quickly from 4 standard items in 5 pipe sizes. Capacity easily enlarged or reduced by adding or subtracting standard sections. Compact construction to save plant room. No special supporting structure needed. Write for catalog section S-6780.





Concentric Tube exchangers: Available in two types. Series 10A is small, low-priced, gives true counterflow. Exceptionally good for small flow rates at narrow temperature differences . . . Series 20A manufactured with "Karbate" inner and outer piping, and is used to transfer heat between two corrosive fluids. Both have sectional construction, can be added to or subtracted from at will. Sturdy, can be moved from place to place after assembly, adapted to any method of mounting on floor, wall, or ceiling. Write for catalog section S-6670.

The term "Karbate" is a registered trade-mark of Union Carbide and Carbon Corporation

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A Division of Union Carbide and Carbon Corporation

30 East 42nd Street, New York 17, N. Y.

District Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

In Canada: National Carbon Limited
Montreal, Toronto, Winnipeg

A full line of "Karbate" impervious graphite pipe and fittings

for conveying corrosive chemicals includes: "Karbate" pumps of advanced design embodying impervious graphite case, impeller, and a rotary seal which eliminates the stuffing box. Pump prices reduced up to 33%. Write for catalog section S-7000 for pipe information, S-7200 for pump information.

Personnel News...

John F. Black has accepted an appointment with the Freyn Engineering department of Koppers Co., Inc. He was formerly with the Youngstown Sheet and Tube Co. as assistant general superintendent of the East Chicago, Ind., works, and had prior service with Bethlehem Steel Co., Atlas Steels, Ltd., and Colorado Fuel and Iron Corp. Mr. Black had been serving as president of the Association of Iron and Steel Engineers.

Robert N. Merk has been appointed chief engineer of Sharon Steel Corp., Sharon, Pa. Mr. Merk has been superintendent of the galvanizing and panel department of the H. H. Robertson Co., Ambridge, Pa., for the past four years. Prior to that time he was connected with U. S. Steel Corp. and was assistant to the chief engineer at Homestead works from 1945 to 1948. He had previously served as assistant power and fuel engineer and as assistant to the open hearth superintendent.

Roy P. Tooke has been appointed manager and **E. T. Mitchell,** general superintendent of the Butler, Pa., division of Armco Steel Corp. Mr. Tooke fills the vacancy caused by the death of J. Gordon Gage on June 16. Prior to that time he had been general superintendent of the Butler division. Mr. Mitchell, who has been assistant general superintendent, succeeds Tooke as general superintendent.

James W. Kent, supervisor of material control at the Fontana works of Kaiser Steel Corp., has been promoted to the position of buyer, scrap procurement. Mr. Kent will transfer his office immediately from the Fontana works to the Los Angeles, Calif., district sales office.

Curtis Bonneville was appointed general foreman of Kaiser Steel Corp.'s merchant-skelp mill at Fontana, Calif.

Rodger J. Mueller has been appointed manager of Falk Corp.'s Youngstown, Ohio, office. **F. J. Bowers,** who has represented Falk for many years in the Youngstown area, will remain in the Youngstown office in an advisory and consulting capacity. **D. B. Bodholdt** succeeds Mr. Mueller in the Falk Pittsburgh office.

Brooks Kitchel was appointed purchasing agent, Fontana, Calif., works of Kaiser Steel Corp. Mr. Kitchel was formerly superintendent of stores. He replaces **R. N. Sturtridge,** who has resigned. Replacing Mr. Kitchel will be **E. W. Holbrook,** assistant superintendent of stores.

H. H. Wunderlich was named treasurer of Jones & Laughlin Steel Corp., Pittsburgh, Pa., succeeding **Hampson Carey** who died recently. Mr. Wunderlich has been acting in the capacity of assistant vice president-general services.

John E. Ward has been appointed chief inspector for the Youngstown, Ohio, district of Youngstown Sheet and Tube Co. Mr. Ward succeeds Lewis W. Fogg, Jr., who died May 14.

James J. Riley was named works auditor for the South Chicago, Ill., works of United States Steel Co.

George C. Brainard, Jr., assistant superintendent of the cold strip mill at Campbell, Ohio works of Youngstown Sheet and Tube Co., has gone to Cambridge, Mass., to spend a year at Massachusetts Institute of Technology under the Sloan Fellowship Program.

William E. Saupe has been appointed operation manager, and **Will Pruessman** has been named manager of manufacturing of the Schenectady steam turbine and generator divisions of the General Electric Co.

A. T. Chandonnet has been appointed manager of General Electric Co.'s Lynn, Mass., turbine division. Mr. Chandonnet was assistant to the vice president in charge of manufacturing policy.

JOHN F. BLACK

ROBERT N. MERK

ROY P. TOOKE

E. T. MITCHELL

John A. Baldinger, assistant general manager of the Philadelphia division of Yale & Towne Manufacturing Co., returned to Chicago, Ill., to become general manager of the Automatic Transportation Co.

S. J. Merriman has been appointed assistant to the general manager of the East Pittsburgh, Pa., divisions of the Westinghouse Electric Corp. Mr. Merriman, formerly assistant to the manager of the transportation and generator divisions, will have responsibility for the administration of budgets, controlling inventory investment, and general supervision of office service activities.

Edward F. Myers, chairman of the board of Ironton Fire Brick Co., has re-assumed the duties of general manager following the death of **Cecil E. Bales.**

J. Franklin Miller is now associated with the Freyn Engineering department of the Koppers Co., Inc., Chicago, Ill., as a contract engineer. Mr. Miller was with Tata Iron and Steel Co., Jamshedpur, India, as assistant chief engineer and development engineer until he terminated his association to join Freyn Engineering.

James W. Liddell has been appointed manager of high-temperature insulation products of the Armstrong Cork Co., Lancaster, Pa. Mr. Liddell succeeds **F. W. Muller** who has resigned. **Warden N. Hartman** has been appointed manager of the industrial insulation department, succeeding Mr. Liddell.

Charles B. Cobun, for many years associated with the United States Steel Co., has joined the Chicago, Ill., district sales office of Heppenstall Co.

John J. Alexander has been appointed superintendent of steam and power at Republic Steel Corp.'s

JOHN J. ALEXANDER

Cleveland, Ohio, district. Mr. Alexander succeeds **Harold Stott,** superintendent of steam and power for the past 36 years at the Cleveland plant, who recently retired. Mr. Alexander has been with Republic since 1941 and for the past 10 years has been assistant superintendent of power.

Heroult

ELECTRIC MELTING FURNACE

. . . as ever, the dependable furnace for the production of high-grade stainless, alloy and rimming steels.

Removable roof of new design now available for the larger furnaces.

AMERICAN BRIDGE COMPANY

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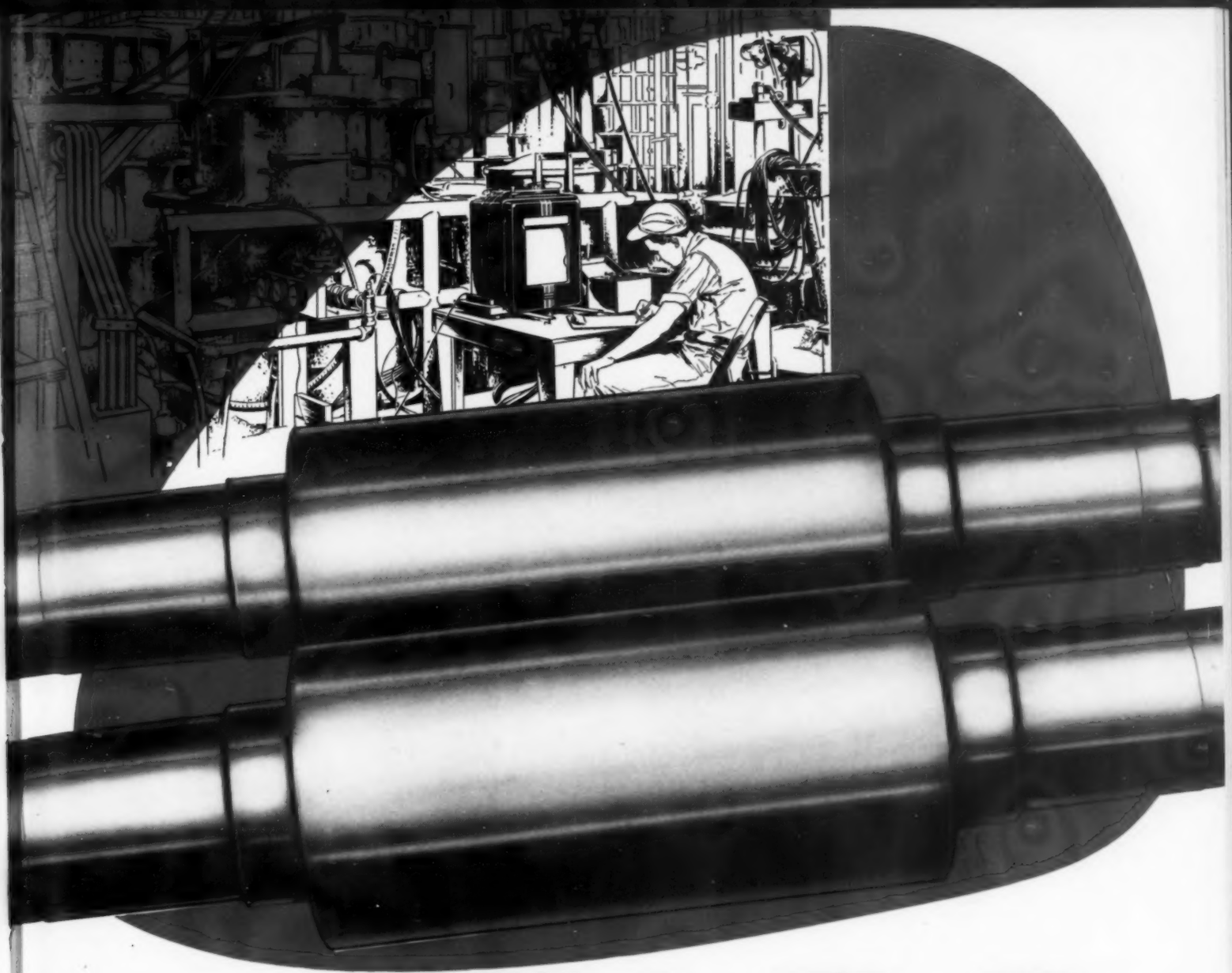
USS

AMERICAN BRIDGE

UNITED STATES STEEL



Ohio Rolls

SHAPING METAL FOR ALL INDUSTRY

made better by a system of INTEGRATED PROCESS CONTROL

Select from any of these eleven types of Ohio Steel and Iron Rolls:

Carbon Steel Rolls	Denso Iron Rolls
Ohioloy Rolls	Nickel Grain Rolls
Ohioloy "K" Rolls	Special Iron Rolls
Holl-O-Cast Rolls	Nioloy Rolls
Chilled Iron Rolls	Flintuff Rolls

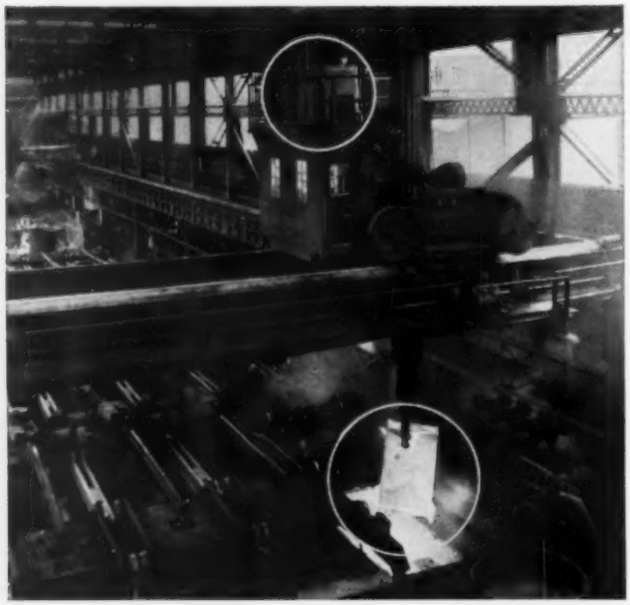
Alloy Chilled Iron Rolls

Order Ohio Steel or Iron Rolls, and be sure of highest quality. A team of specialists—metallurgists, chemists, engineers, inspectors—works as a closely-knit group, supervises every step in filling your order. We refer to their over-all direction as INTEGRATED PROCESS CONTROL.

THE OHIO STEEL FOUNDRY CO. LIMA, OHIO

PLANTS AT LIMA AND SPRINGFIELD, OHIO

J&L STEEL *uses...* **DRAVO CRANE CAB COOLERS** *in its "HOTTEST SPOT"*



SOAKING PIT OPERATIONS MADE MORE EFFICIENT, WORKING CONDITIONS BETTER

The hottest spot in any steel mill crane operation is over the soaking pit. Temperatures range as high as 170° F.; dirt, dust, fumes and gases limit the time any man can work his crane over this installation.

Jones & Laughlin Steel Corporation has eliminated this working hazard by installing Dravo Crane Cab Coolers on the cranes working over these hot spots.

CRANE CAB COOLERS HAVE LONG SERVICE LIFE, PROVIDE YEAR-'ROUND AIR CONDITIONING

Dravo Crane Cab Coolers are ruggedly constructed, factory assembled and pre-tested to provide years of more-than-satisfactory service. All equipment in the unit is readily accessible with ample space for quick and efficient maintenance.

In the various air conditioning functions the crane cab cooler not only filters the air, removes dust, dirt and fumes, but heats the cab in winter, cools it in summer and provides constant ventilation the year around.

AVAILABLE IN SINGLE UNIT OR IN SPLIT-TYPE UNIT; IMMEDIATE DELIVERY

Dravo Crane Cab Coolers are built in two models—the self-contained unit, mounted on any available space on the crane and the new split-type unit where the condenser section is mounted on the crane, with the conditioning section in cab.

The Dravo Crane Cab Cooler can be easily and quickly installed on any type of crane with a minimum of down-time required. Units are available now! Write for more information —or phone the nearest Dravo Office and have our representative call on you.

DRAVO **DRAVO CORPORATION**

DRAVO BUILDING, PITTSBURGH 22, PA.

PITTSBURGH • PHILADELPHIA • CLEVELAND • NEW YORK • CHICAGO
DETROIT • ATLANTA • BOSTON

Leighton F. Korb has joined the Freyn Engineering department of the Koppers Co., Inc., Chicago, Ill., as a contract engineer. Previous to joining Freyn, Mr. Korb was general manager of the National Steel Co. of Brazil at Volta Redonda, Brazil.

A. H. Borchardt has been elected a vice president of Worthington Pump and Machinery Corp., Harrison, N. J. Mr. Borchardt will have the overall responsibility for the sale of the corporation's entire line of pumping equipment, including centrifugal, reciprocating and vertical turbine pumps.

Ellsworth W. Hudgens has been added to the staff of Dowell, Inc., as a development engineer specializing in cathodic protection for retarding electrolytic corrosion of pipelines, industrial equipment and other buried and submerged metals. Mr. Hudgens, who will be located in Dowell's general office in Tulsa, Okla., was formerly with the Gulf Oil Corp.

John E. Renner was named general sales manager of Lincoln Engineering Co., St. Louis, Mo.

JOHN E. RENNER

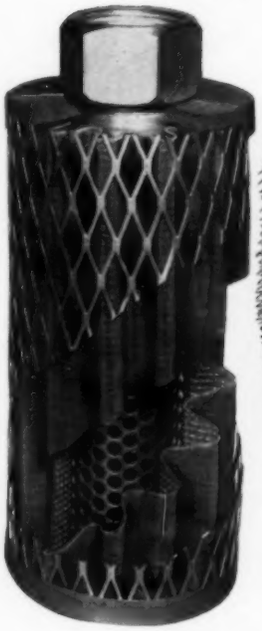
Addison Maupin, formerly ceramic engineer for the Cleveland district of Republic Steel Corp., was recently named a special development engineer for Chas. Taylor Sons Co., Cincinnati, Ohio.

Thomas A. Shaw was appointed sales engineer for Amsler Morton Corp., Pittsburgh, Pa. Mr. Shaw, for the past sixteen years, had been connected with the United States Steel Co. in construction engineering and general steel and rolling mill design.

William V. O'Brien, a commercial vice president of General Electric Co., has been appointed manager of the firm's apparatus marketing division. Mr. O'Brien, formerly assistant manager of General Electric marketing policy, succeeds **Chester H. Lang,** vice president, who now heads the firms public relations organization. Mr. O'Brien will be located at company headquarters in Schenectady, N. Y.

William K. McGreevy has been appointed sales representative of the Pittsburgh, Pa., regional office of the Philadelphia division, Yale & Towne Manufacturing Co.

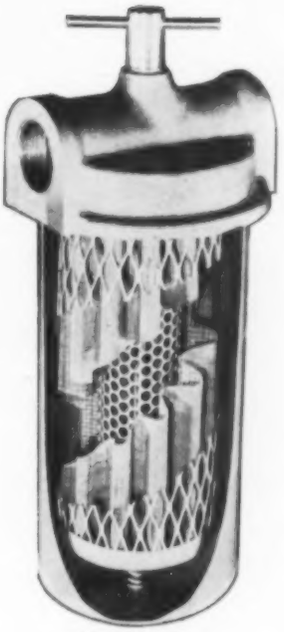
Simplify Your Preventive Maintenance



with

MARVEL SYNCLINAL FILTERS

SUMP TYPE
(Cutaway)



LINE TYPE
(Cutaway)

For All Hydraulic Systems

SIMPLE EFFICIENT DESIGN REDUCES DEMAND ON YOUR SKILLED MAINTENANCE HELP

ANY WORKMAN can disassemble, clean and reassemble Marvel Synclinal Filters. Cleaning is done quickly, and Marvel's extra capacity requires less frequent cleanings. This means more production per machine with less man hours. Marvel protected machines spend their time producing, not in being serviced and repaired. Marvel's simple efficiency changes down-time to producing time.

STANDARDIZE WITH MARVEL

Choice of Over 200 Original Equipment Manufacturers

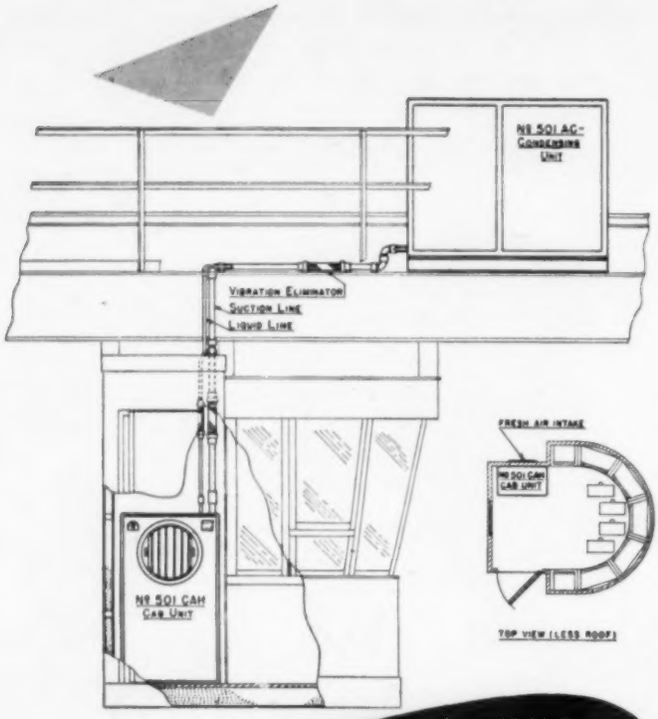
Improve your all-important preventive maintenance by simplifying it. Use Marvel Synclinal Filters throughout your plant. Specify Marvel on new machines, add Marvel to present machines. No moving parts to wear, nothing to keep in stock. Your first cost is your only cost.

Meets JIC Standards

Available in capacities of 5 to 50 gpm, and in mesh sizes from 30 to 200. Multiple installation provides capacities as great as you may require. Depend on Marvel for efficient filtration of non-corrosive liquids in all hydraulic and low pressure systems.

Write for Folder 105

MARVEL ENGINEERING COMPANY
625 W. Jackson Blvd. Chicago 6, Ill.



How to Save 2/3 on Your Crane Cab Air Conditioning

By arranging for air conditioning with the Lintern Aire-Rectifier *when buying the crane*, the cost is only about one-third that of installing air conditioning later.

A majority of the steel companies, in their expansion programs, have included air conditioned crane cabs.

Aire-Rectifiers hold cabs at a cool 85° F and relative humidity of 30% to 50% at ambient temperatures of 170° without excessive head pressures or wear on the machine.

In the split system (shown above) the condenser is located at any convenient place on crane, and evaporator (cooling coil) is placed in cab. The two units are connected with refrigerant lines properly secured and protected against breakage. Condensers are air-cooled, assuring trouble-free service with but little maintenance.

May we send you complete information on the Lintern Aire-Rectifier (patents pending) and its application to your particular needs?

THE LINTERN CORPORATION

29-2 RIVERSIDE DRIVE • BEREA, OHIO

Dr. Louis T. Rader has been appointed manager of engineering of General Electric's control divisions at Schenectady, N. Y. **Harry L. Palmer** was named assistant to the manager of engineering of the control divisions and **Benjamin Cooper** as division engineer of the electronics and regulator engineering division.

George V. Luerssen, formerly chief metallurgist, was appointed vice president in charge of metallurgy for Carpenter Steel Co., Reading, Pa. He succeeds **B. H. DeLong,** who announced his retirement as vice president and technical director after 41 years of continuous service. **Dr. Carl B. Post** succeeds Mr. Luerssen as chief metallurgist, and **George E. Brumbach** advances to the position of metallurgist to succeed Mr. Post.

A. C. Bishop was elected chairman of the board for Ferro Engineering Co., Cleveland, Ohio; **G. A. Peterson** was named president, **Walter M. Charman, Jr.,** becomes executive vice president and **P. R. Ward** was elected a vice president.

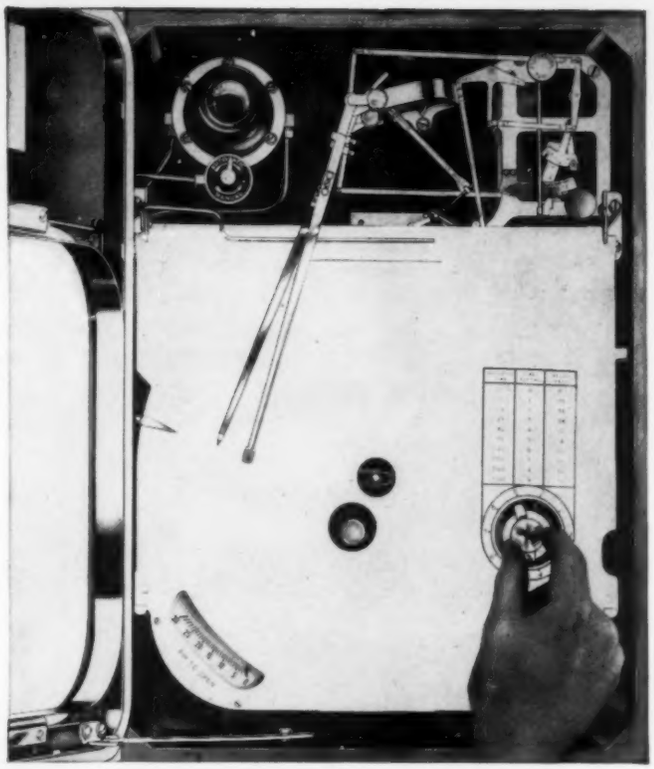
Edward J. McDonnell, vice president of the Blaw-Knox division of Blaw-Knox Co. in charge of steel

H. RUSSELL LOXTERMAN

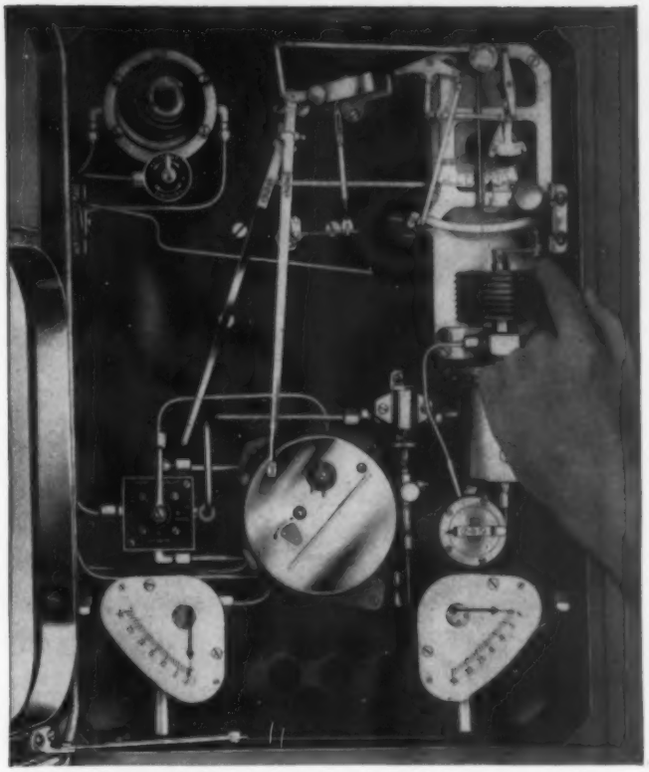
plant equipment, has retired. **H. Russell Loxterman** was appointed manager of the steel plant equipment department.

John L. Hutton, 4811 Carnegie Ave., Cleveland, Ohio, has been appointed northeastern Ohio representative for Dunsford Co., Pittsburgh, Pa. He will handle the district business for Pelham Electric Manufacturing Co., Inc., Green Electric Sales Corp., Electro Dynamic Works of Electric Boat Co., Erie Electric Co., Continental Electric Co., and Nickel Cadmium Battery Corp. Mr. Hutton, a native of Denver, Colo., graduated from Colorado School of Mines and has been associated with General Electric Co., Clark Controller Co., and Hutco Electric, Inc.

B. I. Ulinski was named director of engineering for Automatic Transportation Co., Chicago, Ill. **Ressler A. Dusseau** succeeds Mr. Ulinski as chief engineer of rider-type electric industrial trucks. **Herbert J. Framhein** will continue as chief engineer of the Transporter brand of materials handling trucks, and **Alfred C. Elley** remains chief electrical engineer.



EASIEST TO PUT INTO OPERATION—Calibrated control actions save hours of shutdown. Reset, derivative and proportional values can be exactly reproduced at any time on the same or any other Series 500 controller . . . merely by duplicating the setting. Thus: controller adjustments can be standardized for any process throughout a plant or national organization.



EASIEST TO SERVICE—Inherently simple design, using the fewest possible parts, plus extremely close-tolerance manufacturing . . . make the instrument thoroughly interchangeable, trouble-free and a cinch to service. For example: only one simple adjustment puts the system in exact calibration even after complete disassembly and reassembly.

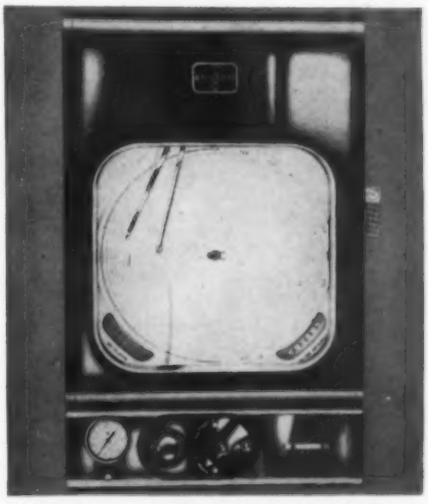
ONLY BRISTOL SERIES 500 CONTROLLERS GIVE YOU THIS EASE OF OPERATION

When you wish to reproduce a previous control action or duplicate one taking place at some other point, the Bristol Series 500 Air-Operated Controller permits you to do it merely by setting a dial.

Or, should the instrument require servicing, only one simple adjustment is needed to calibrate the control system and put it back in operation. Almost anyone can service this instrument.

Furthermore, users report that the Bristol Series 500 Controller requires practically no maintenance.

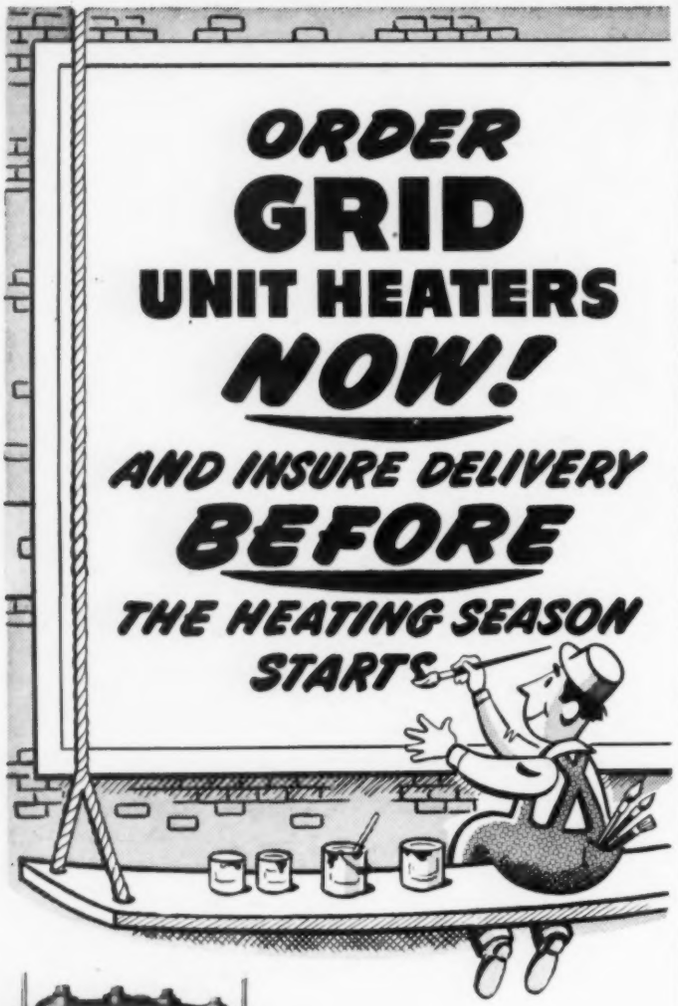
This outstanding instrument—a product of 60 years of experience—is completely described in Bulletin A120. THE BRISTOL COMPANY, 123 Bristol Road, Waterbury 20, Conn.

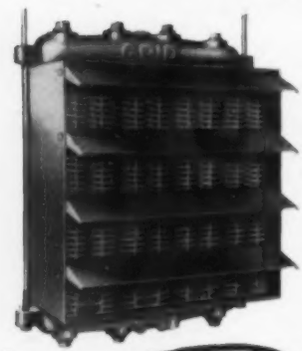


BRISTOL SERIES 500 CONTROLLERS are offered in five types—on-off, proportional, reset, derivative, reset plus derivative—to control temperature, flow, pressure, liquid level, humidity, pH. Conversion from one type to another can be made by the user. Model shown has external-manual station with mechanical interlock for test and service.

BRISTOL

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS





THE UNIT HEATER WITH HIGH TEST CAST IRON HEATING SECTIONS . . . FREE OF ELECTROLYSIS

Double your money's worth—if you order GRID Unit Heaters NOW—in advance of the regular heating season, because our inventory on GRID Unit Heaters is the best in years. And, GRID Unit Heaters are the best heating buy from the standpoint of maintenance-free service and low cost of operation. There is no waiting for delivery on GRID Unit Heaters and there is no maintenance after you get them, because . . .

GRID cast iron construction withstands corrosive fumes.

GRID wide fin spacing facilitates easy cleaning.

GRID will withstand steam pressures up to 250 lbs., and is free of electrolysis.

GRID fins are cast integral with the steam chamber assuring even distribution of heat. It's not possible for GRID fins to come loose from the steam chamber to cause loss of heating efficiency.

GRID design incorporating proper fan sizes, motor speeds and outlet temperatures results in a properly balanced heating unit, especially when high steam pressures are used.

Consult our Engineering Department and Sales representatives for advice on heating problems, including Unit Heaters, Blast Coils and Radiation. Send for complete catalog . . . no cost . . . no obligation.

D. J. MURRAY MANUFACTURING CO.
Manufacturers Since 1883
WAUSAU • WISCONSIN

C. F. Coffin and **J. F. Nounnan** have been appointed district representatives for the construction materials department of General Electric Co. Mr. Coffin has been assigned to the Atlantic district and will be responsible for the conduit products line of the department. His headquarters will be at 1405 Locust St., Philadelphia, Pa. Mr. Nounnan has been assigned to the central district with offices at 409 S. 17th St., Omaha, Neb.

William A. Mallory has been named manager of the mechanical connectors department for National Electric Products Corp., Pittsburgh, Pa. Mr. Mallory also will assist in managing the company's busway department.

Howard E. Hornickel was named works superintendent of the American Steel & Wire Co.'s Donora

HOWARD E. HORNICKEL

zinc works at Donora, Pa. Mr. Hornickel succeeds **M. M. Neale,** who has been associated with the Donora zinc works since its establishment in 1915 and has been works superintendent since 1946. Mr. Neale retired on July 31.

Bradley Bartlett was appointed as chief engineer of Kling Bros. Engineering Works, Chicago, Ill.

Obituaries

Walter M. Charman, 57, president and founder of Ferro Engineering Co., Cleveland, died June 15.

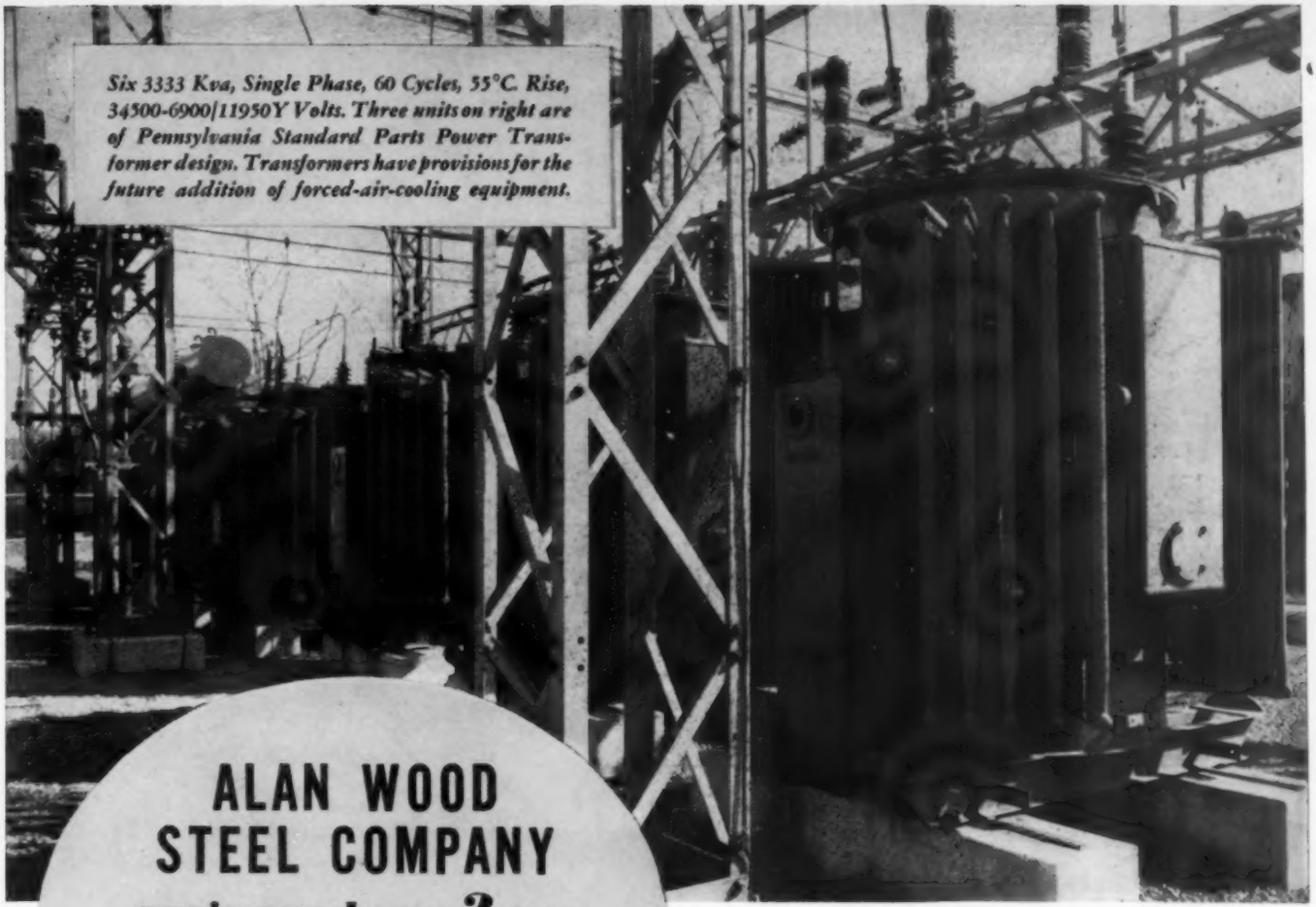
Corrosion Proof Construction Materials

CEMENTS FLOORS LININGS COATINGS

Rely on Atlas' years of experience and recognized leadership to help solve your problems. Write 65 Walnut Street, Mertztown, Pa.

Over a half century of service

Atlas
MINERAL PRODUCTS COMPANY
MERTZTOWN, PA. HOUSTON, TEXAS



Six 3333 Kva, Single Phase, 60 Cycles, 55°C. Rise, 34500-6900/11950Y Volts. Three units on right are of Pennsylvania Standard Parts Power Transformer design. Transformers have provisions for the future addition of forced-air-cooling equipment.

ALAN WOOD STEEL COMPANY

again purchases 3 new PENNSYLVANIA STANDARD PARTS POWER TRANSFORMERS

Pennsylvania TRANSFORMERS

RECENTLY, three new Pennsylvania Power Transformers, with a total rating of 10,000 Kva, were put into service alongside three older Pennsylvania Transformers with a similar rating. Though both banks of transformers have the same electrical characteristics, there is a decided difference between the old and the new group of transformers. The new units are Pennsylvania Standard Parts Power Transformers, which have certain distinct advantages for the user:

1. Definite savings are effected by the purchase of Pennsylvania Standard Parts Power Transformers. These savings are made possible by the use of standard designs, standard parts, and standard methods of manufacturing, which shorten engineering and production time.

2. The purchaser is able to select the method of oil preservation that he prefers without any price penalty. The transformers illustrated above are equipped with an inert gas, oil pressure system.

3. The transformers feature the many new design improvements built into Pennsylvania Standard Parts Power Transformers. Included are:

   A. a new improved structural steel base which simplifies the important problems of jacking, pulling, rolling and painting;

   B. a new streamlined radiator designed to facilitate cleaning and painting in the field.

For more complete information on Pennsylvania Standard Parts Power Transformers, write to Pennsylvania Transformer Co., Box 330, Canonsburg, Pa.

What are Pennsylvania Standard Parts Power Transformers?

They are single phase transformers in sizes up to 5000 Kva, 69 Kv, and three phase transformers in sizes up to 10,000 Kva, 69 Kv. Transformers are "Standard" when they conform to standard voltage ratings, have standard taps and standard impedances, and are equipped with standard accessories in standard locations. For such transformers a full discount is applied. When voltages are not standard, but within a certain voltage range, slightly lower discounts are applied.

Pennsylvania

TRANSFORMER COMPANY

CANONSBURG, PA. • *Greater Pittsburgh District*

WHAT'S THE BEST WAY TO CLEAN LARGE METAL PARTS?

This FREE Oakite Booklet Tells How

HERE'S an easy, low-cost way to clean metal parts that are too large to be soaked in tanks or conveyed through washing machines.

Just use the Oakite Solution-Lifting Steam Gun to apply an Oakite cleaning solution under about 40 pounds of steam pressure. Oil, grease and other dirts vanish quickly, leaving parts ready for inspection, assembly, further machining, pre-paint treatment, etc. (The same gun applies Oakite paint-stripping solutions under low pressure.)

FREE For illustrated folder F7338—telling more about the money-saving Oakite Steam Gun—write to Oakite Products, Inc., 28A Thames St., New York 6, N. Y.

ALSO *ask about Oakite procedures for:*

- **Cleaning in tanks**
- **Cleaning in machines**
- **Electrocleaning**
- **Pre-paint treatment**
- **Pickling**
- **Burnishing**
- **Paint stripping**
- **Rust prevention**

SPECIALIZED INDUSTRIAL CLEANING

OAKITE

TRADE MARK REG. U.S. PAT. OFF.

MATERIALS • METHODS • SERVICE

Technical Service Representatives in Principal Cities of U. S. & Canada

Joseph Henry Towle, 62, in charge of the Philadelphia, Pa., office of the Tool Steel Gear & Pinion Co., for over 20 years, senior member and founder with his late father of Towle and Son Co., of Philadelphia, died July 12, at Philadelphia.

Lawrence E. Riddle, 74, died August 8. Mr. Riddle was formerly superintendent of U. S. Steel Co.'s blast furnaces at Duquesne, Pa., and of the Isabella Furnaces at Etna, Pa. Since his retirement, in 1946, he has acted in an advisory capacity on blast furnaces for several firms.

LAWRENCE E. RIDDLE

Leslie I. Harris, general foreman, hot strip finishing department, Youngstown Sheet and Tube Co., Campbell, Ohio, was killed in an automobile accident June 6.

George P. Dempler, president of George P. Dempler Co., Pittsburgh, Pa., died recently. Mr. Dempler's firm represented several manufacturers in the Pittsburgh district.

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Crane No. 7
150-Pound Brass Globe Valve
with composition disc

You spend less
by using Dependable Quality
CRANE VALVES

. . . That's why more Crane Valves are used than any other make

Disc repairs made in a minute

You save maintenance time and money when you use Crane No. 7 Brass Valves with composition disc. When a leak shows up, you don't change valves . . . just open the bonnet joint and slip on a spare disc holder with a new disc already in it.

And by changing the type of disc, you can adapt No. 7 valves to a wide range of services—steam, hot water, cold water, air, oil, gas, and gasoline. Made in globes and angles; screwed or flanged ends.

Simplified maintenance and complete adaptability to your service typify Crane Quality valves and fittings for every need. That's why they cost less in the long run.

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General Offices:
836 S. Michigan Ave., Chicago 5, Ill.
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VALVES • FITTINGS • PIPE • PLUMBING • HEATING

WATCH FOR THE 1951

Iron & Steel Daily News

Five big issues covering the Annual Convention of the Association of Iron and Steel Engineers to be held October 1, 2, 3 and 4, in the Hotel Sherman, Chicago, Ill.

1951 PUBLICATION DATES:

September 17 (Pre-Convention Issue), October 1, 2, 3 and 4

Jones

ROLLER BEARING PILLOW BLOCKS

JONES Pillow Blocks are made in sizes to take shafts 1 3/16" to 9" in diameter. Equipped with double row Timken roller bearings. Engineered and designed for the most efficient solution of your drive problems. Ask for Bulletin No. 86.

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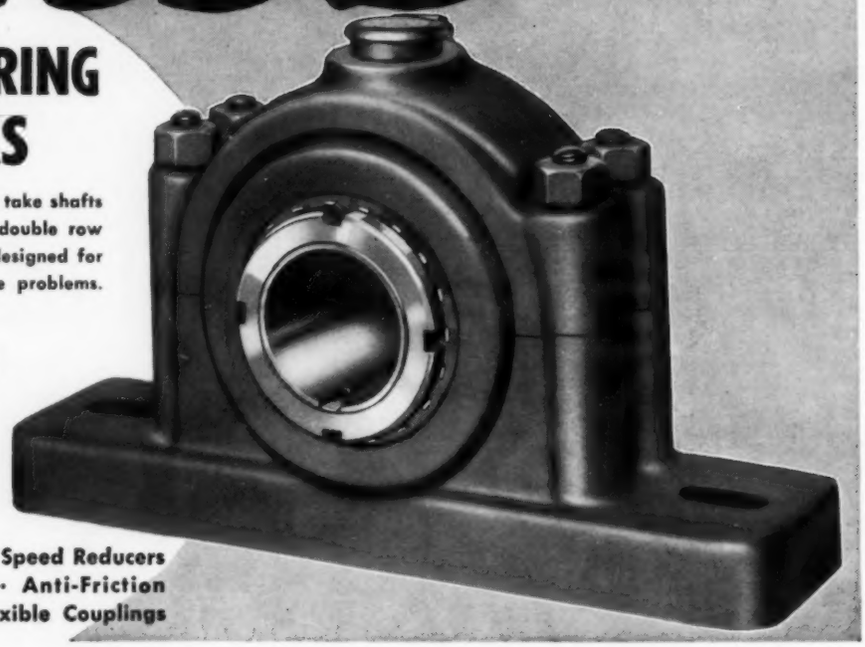
4431 W. Roosevelt Rd., Chicago 24, Ill.

Since 1890
Jones
In the Service of Industry



Herringbone — Worm — Spur — Gear Speed Reducers
Pulleys · Gears · V-Belt Sheaves · Anti-Friction Pillow Blocks
Flexible Couplings

STOP RUST WITH RUST-OLEUM

Why let rust—the most destructive enemy of American Industry—rob you of expensive, hard-to-replace machines, tanks, stacks, fences, pipe, metal sash, fire escapes, and other valuable equipment?

Use RUST-OLEUM in your plant to protect your property. For 25 years RUST-OLEUM has proved its capacity to stop rust for many nationally known manufacturers. Its tough, pliable, rust-resisting film gives excellent protection that prevents rust losses under many difficult rust-producing conditions—salt air, dampness, industrial fumes, and general weathering.

RUST-OLEUM can be applied *even* over rusted surfaces. It is not necessary to remove all the rust. Just remove scale and loose rust by chipping, scrapers and wire brushes. You save time and labor on maintenance because no chemical precleaning or sand blasting is usually required.

A qualified RUST-OLEUM specialist will be glad to survey your rust problems and help you develop a program of plant-wide rust control to defer many costly replacements — to conserve the available supply of new metal for national defense.

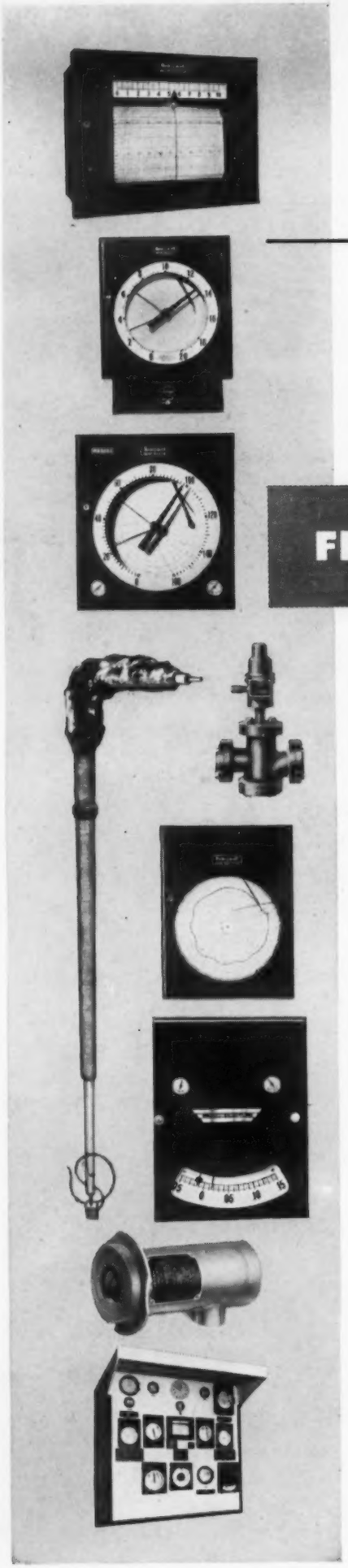
Industrial Distributors in principal cities of the United States and Canada carry complete stocks for immediate delivery. Plan your needs—order *now!* See our complete catalog in *Sweet's* which also tells the nearest source of supply. Or, write on your company letterhead for full information.

"RIGID ECONOMY, MON!"

Available in many COLORS aluminum and white

Beautifies as it Protects

RUST-OLEUM CORPORATION
2443 Oakton Street, Evanston, Illinois



Brown Instruments

HELP YOU PRODUCE... MORE EFFICIENTLY... MORE ECONOMICALLY

FROM ORE...TO IRON...TO STEEL

WHEREVER steel is produced . . . wherever it is treated, formed, and fashioned into its innumerable end uses . . . there you will find Brown instruments, control systems and services helping make *better steel*, and *better steel products*, at lower cost.

Brown instruments have advanced through the years . . . with the industry's leaders . . . always in step with the needs of tomorrow, meeting the exact specifications of each new technique.

Brown serves the metals industry by making available:

COMPLETE INSTRUMENTATION—The world's largest selection of unit control systems cover operations ranging from mining ore to automatically controlling the finish of a delicate manufactured product. Every encountered variable: temperature—pressure—pH—conductivity—flow—speed—motion—thickness—smoke—haze—dust—combustion—gas analysis, etc., is efficiently indicated, measured, recorded or controlled.

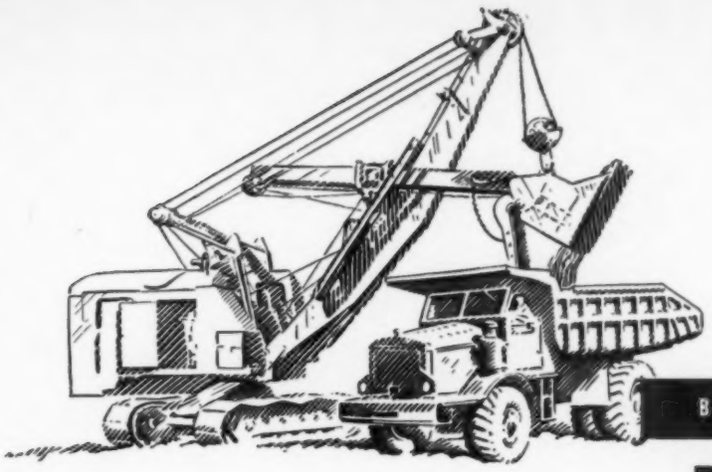
SERVICE AND MAINTENANCE—The world's largest instrument service organization to keep these industries operating at peak efficiency.

TRAINING SCHOOL—trains industry personnel to obtain maximum benefits and continuous life from instruments and control systems.

INDUSTRY SPECIALISTS—located in all major producing areas provide practical, constructive help in industry's problems.

HSM PLAN—makes possible new convenience and savings in the purchase of pyrometer supplies.

COMPREHENSIVE LITERATURE—catalogs, bulletins and specification sheets on products and systems . . . Instrumentation Data Sheets on practical industry applications.



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Beneficiation, flotation, sintering,

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forging furnaces, roughing mills and

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pickling, cleaning, and annealing,

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...TO FINISHED PRODUCTS

TO

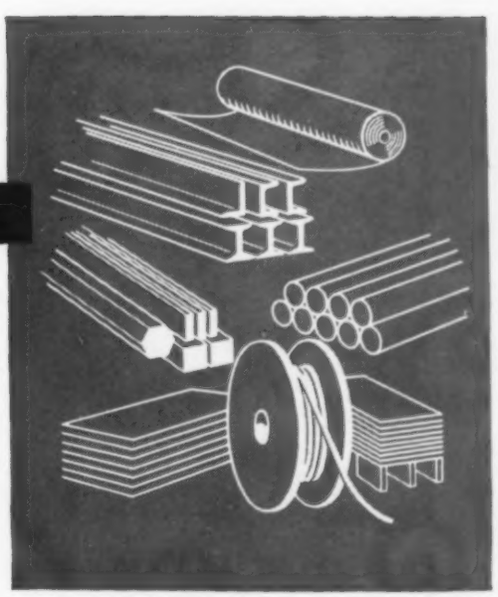
Measure, record and control

(pneumatically or electrically),

pressure, temperature, speed, motion,

thickness, pH, flow, gas analysis,

smoke, haze and dust, combustion.



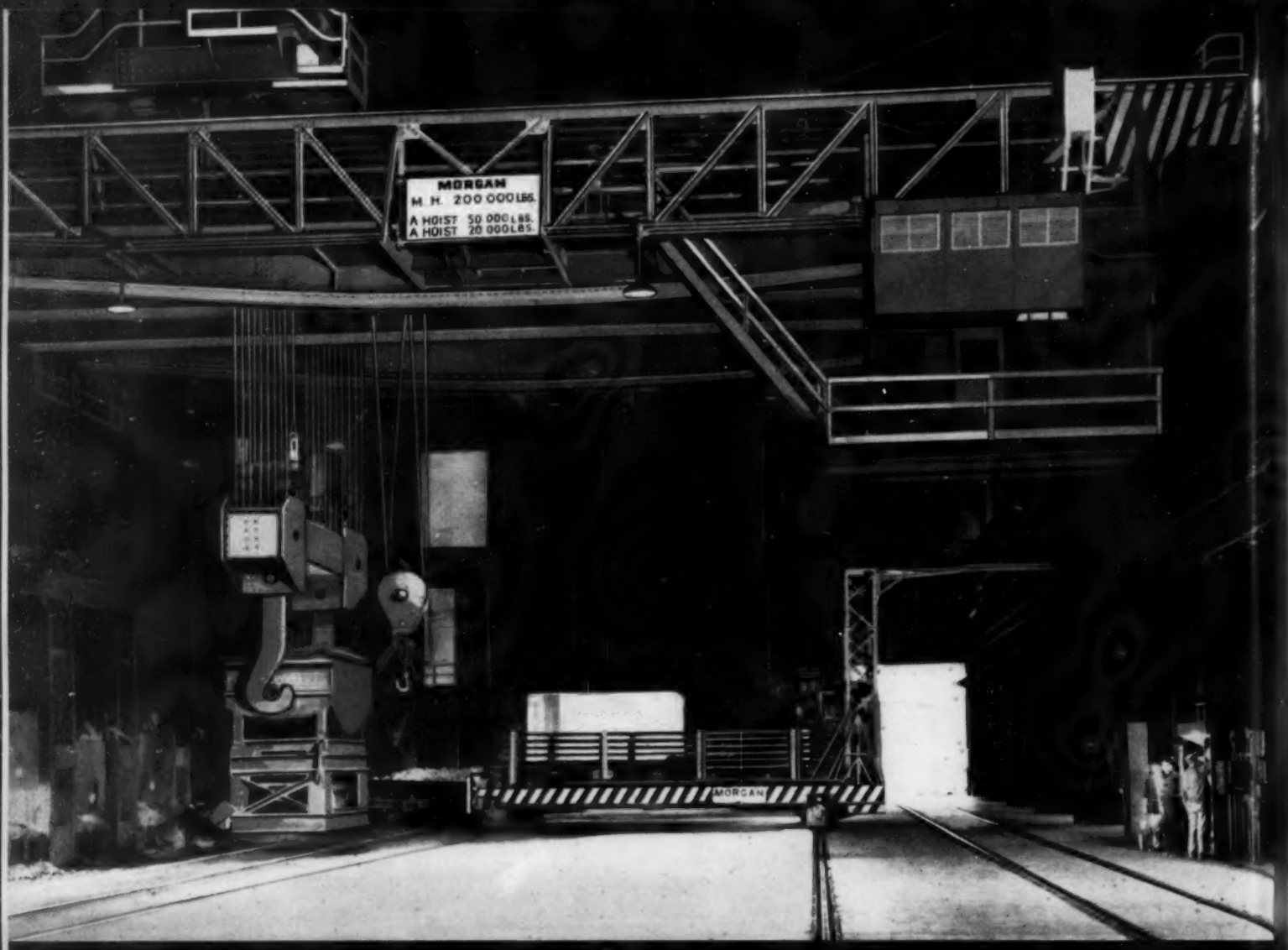
Information on any specific instrumentation problem will be furnished upon request. Write, or call in our local engineering representative . . . he is as near as your phone!

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4464 Wayne Ave., Phila. 44, Pa.

MINNEAPOLIS

Honeywell

Brown Instruments



Illustrated is a 100-ton, 80'-0" span, 4-girder type Ladle Crane and a 7½-ton, 26'-0" span Floor Charger.

BUILT BY MORGAN Engineering

Morgan equipment is built to last a long time as Morgan engineers rely upon a highly skilled shop organization, modern equipment, and progressive ideas in building Morgan steel mill machinery.

THE MORGAN ENGINEERING CO.
ALLIANCE, OHIO
PITTSBURGH—1420 OLIVER BUILDING

DESIGNERS • MANUFACTURERS • CONTRACTORS • BLOOMING MILLS • PLATE MILLS • STRUCTURAL MILLS • ELECTRIC TRAVELING CRANES • CHARGING MACHINES • INGOT STRIPPING MACHINES • SOAKING PIT CRANES • ELECTRIC WELDED FABRICATION • LADLE CRANES • STEAM HAMMERS • STEAM HYDRAULIC FORGING PRESSES • SPECIAL MACHINERY FOR STEEL MILLS

Equipment News...

TWO-WAY RADIO SYSTEM

▲ Installation of a two-way radio communication system has been completed at the West Allis works of Allis-Chalmers Manufacturing Co.

The new system gives the works' transportation department complete control over its hauling vehicles at all times. To date, transmitter and receiver units have been installed in 22 department vehicles. These include diesel locomotives, trucks, derricks, tractors, and a dispatcher's car.

Movement of all radio-equipped vehicles at the plant is controlled through two central points, the dispatch office and the scale house. The former handles all truck assignments and the latter all locomotive and derrick jobs.

The new system greatly facilitates movement of materials and products around the plant and into and out of the area. It is highly effective in intercepting trucks within a 30-mile radius of the plant as well as immediately ascertaining the location of trailers dropped at various points within the 155-acre plant area.

The radio system is in operation 24 hours a day. Its antenna is located atop a water tower in the plant area and the transmitter is housed in the heating shed directly below.

FLOW METER

▲ A new type of flow meter which has functional design, gives fast and accurate response over an entire range and features low initial cost and maintenance has been developed by Minneapolis-Honeywell Regulator Co.

Engineers of the Brown Instruments Division said the new flow meter includes such important advantages as an evenly graduated meter scale and electronic integration. It is available either as a mechanical flow meter with integral recorder, or as an electrical transmitter to be used with a Brown inductance bridge receiver.

The new meter is of the differential type, readily installed on a flow line. The meter body is mounted in a convenient location near the line, and the differential pressure lines from the orifice (or other primary element) are piped into the half-inch connections provided on the meter.

For electrical transmitting meters, a three-conductor cable is run between the meter body and the remotely mounted receiver. The new meter is supplied in three ranges: 53, 119.25 and 212 in. of water, and for 750 and 1,500 psi static pressure. For dry calibration the three ranges are slightly greater.

AUTOMATIC RING PACKING

▲ Johns-Manville has developed a new automatic ring packing called "Uneepac." It is a molded packing and each ring is a complete, self-contained packing unit.

The new packing is particularly valuable in the design of new equipment and opens the way for many desirable savings. It is designed for maximum sealing efficiency in minimum packing depth so stuffing box sizes can be reduced. This saves space and cuts machining costs. No follower or header rings are needed. This saves assembly time. Each ring centers itself perfectly on the preceding ring. This reduces the chance of human error. In service, each lip is always exposed to fluid pressure. This provides instantly responsive, positive sealing and, since the packing does not depend on gland pressure for sealing, friction is reduced and there is less wear on both rod and packing.

The packing is offered in varied compositions to suit different services—water, steam, oil, air, gas, vacuum and so forth. It is furnished in sets of endless or split rings. "Uneepac" is available for shafts $\frac{5}{8}$ in. diameter and up.

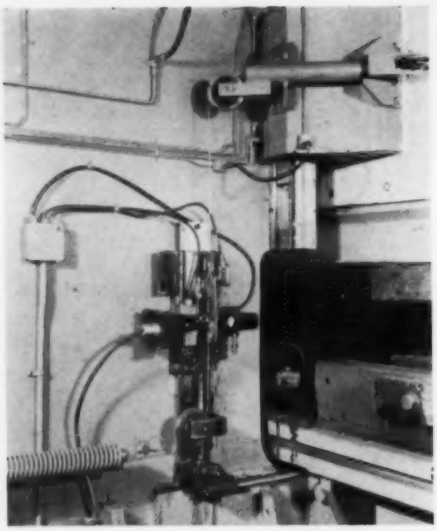
ELECTRONIC RAM CONTROL

▲ What is believed to be the first press brake ever to utilize photoelectric control of the "ram" motion has been constructed by the Verson Allsteel Press Co.

Through use of the General Electric electronic system, the ram may be held completely level through its stroke, or may be operated at a preselected degree of tilt down to a thousandth of an inch.

SELF-PROPELLED, REVOLVING BELT CONVEYOR

This is a Link-Belt built 100-ft radius, self-propelled, revolving, belt conveyor stacker at the end of a 36-in. wide roller bearing belt conveyor system approximately a mile long, discharging overburden into a hollow in the process of uncovering the ore body at the Gross-Marble mine of Oliver Iron Mining Co., Marble, Minn., on the Mesabi Iron Range. The overburden consists of clay, sand, gravel, glacial boulders and lean ore. The conveyor handling capacity is 1140 long tons per hour.



The "ram" motion can be held completely level with this new control.

The new press brake is hydraulically operated. The ram is actuated by two independent hydraulic cylinders supplied from separate matched pumps. A reversible booster hydraulic pump is used to transfer oil from one line to another to maintain position synchronization of the ends of the ram.

The booster pump is driven by a motor supplied by an amplidyne generator, which is controlled by the photoelectric system. Any tilt of the ram raises or lowers a barrier suspended between the photoelectric cell and the light source. Movement of this barrier as much as a thousandth of an inch results in automatic correction through altered speed and direction of the oil flow from the transfer pump.

Vertical micrometer adjustment of the electronic units permits the ram to be operated at a selected degree of tilt when required. According to Verson engineers, the electronic ram control is more efficient, more sensitive and easier to operate than the customary mechanical tie or valve-and-limit-switch methods.

General Electric equipment on the new machine includes a 100-hp a-c induction motor to drive the main pumps, a 3-hp, d-c motor, powered by a 3-kw amplidyne generator, to drive the transfer pump; magnetic controls to start the drives and actuate the valves, and electronic controls for the amplidyne drive.

The developmental model of the new press brake has been fully tested and now is being used by Verson in its own manufacturing operations. The firm reports that eleven of these heavy-duty brakes already are on order, and that additional orders are expected to be booked by the end of the year.

PLANT FLOOR REPAIR

▲ To avoid loss in down time required for making necessary repairs to coke oven floors, a unique method is being used for making quick replacement.

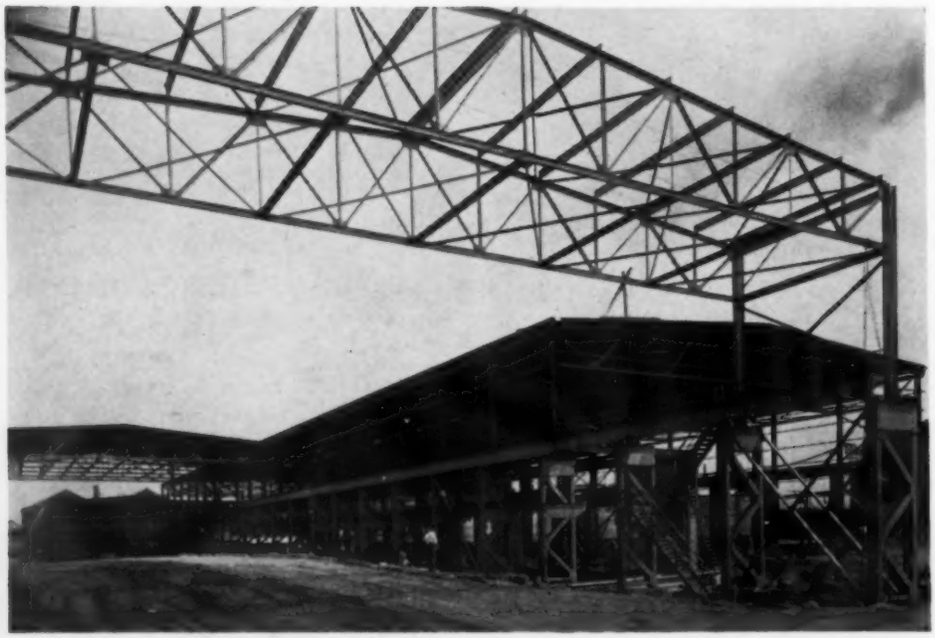
The coke oven floors are thoroughly cleaned of slag and particles of coke and carbon are burned out. Then Refractory & Insulation Corp's. refractory cement is mixed with water thin enough to flow down a chute (or bazooka) which distributes the mortar evenly over the floor to the normal level of the brick floor. One-half the floor is poured from one side and the other half from the other side.

Due to the residual heat in the

AT THE NEW J&L ROD MILL IN ALIQUIPPA

YORK

- Designed and wrote specifications for all buildings and their foundations and for the motor room.
- Designed foundations for all mill equipment, built by United Engineering & Foundry Company, and for motor room equipment.



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Compensator mechanism

Complete compensator

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For Grain Processing Machines

Grinding Mill Installation

Many industrial plants rely on EC&M auto-transformer 220-550 volt Motor Starters for continuity of production. Oil-immersed, these starters are always well lubricated and protected from corrosion — *the need for frequent inspection or maintenance is eliminated.* Motor circuits are made and broken under oil—thoroughly safe, no dust hazards.

The compensator mechanism uses a simple, double-throw contactor requiring only one magnet coil—transition from reduced voltage starting to full voltage running is *automatic.* Squirrel-cage or synchronous motors are brought up to speed quickly, safely—with greater skill than human hands could do it.

Overload relays give inverse-time-element protection and also *trip instantly* on heavy over-currents. A magnetic balance in each relay absorbs heavy starting currents and allows a *low* current setting for accurate protection under running conditions.

Write for Bulletin 1045 and No. 19 ACCELERATOR Bulletin

THE ELECTRIC CONTROLLER & MFG. CO.
2698 EAST 79TH STREET • CLEVELAND 4, OHIO

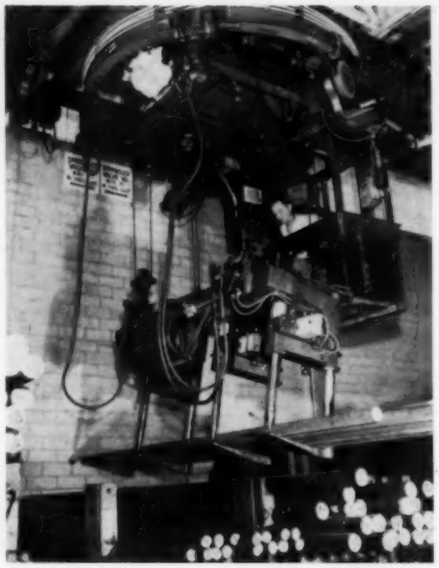
oven, the refractory cement sets immediately to flint-like hardness, remaining abrasion resistant to a marked degree under the difficult conditions that obtain at the high temperature in the oven.

Pusher rams are run through the oven several times to level off any blisters that may form in the rapidly hardening cement. Two-inch wooden planks are then placed on the floor. The planks provide a charcoal lubricant for pushing the first load of coke along the new floor. The doors are then sealed with a clay known as "Luting Mud." Whereupon the coke oven is charged immediately with coal and put back into operation.

BAR STOCK HANDLING

▲ This specially-built, 3-ton capacity, double-bridge, monorail crane handles 4,500,000 lb of bar stock annually in General Electric's small and medium motor divisions, manufacturing operation at Lynn, Mass.

Main element of the equipment is the grab, a steel frame suspended by pulley and cable, which is equipped with three movable forks and safety prongs. Flexibility of the arrangement provides quick, efficient, and selective handling of stock that consists of 12 shapes, 75 specifications, and 800 sizes.



Main element is the grab, a steel frame suspended by pulley and cable.

Seven control functions are involved in the crane's operation: longitudinal and cross travel of the cab, rotation of cab and grab (360 degrees), vertical travel of grab (floor clearance from 1 in. to 9 ft 6 in.), tilting of grab (8 degrees forward, 12 degrees backward), rotation of forks and prongs (90 degrees), and raising and lowering of prongs.

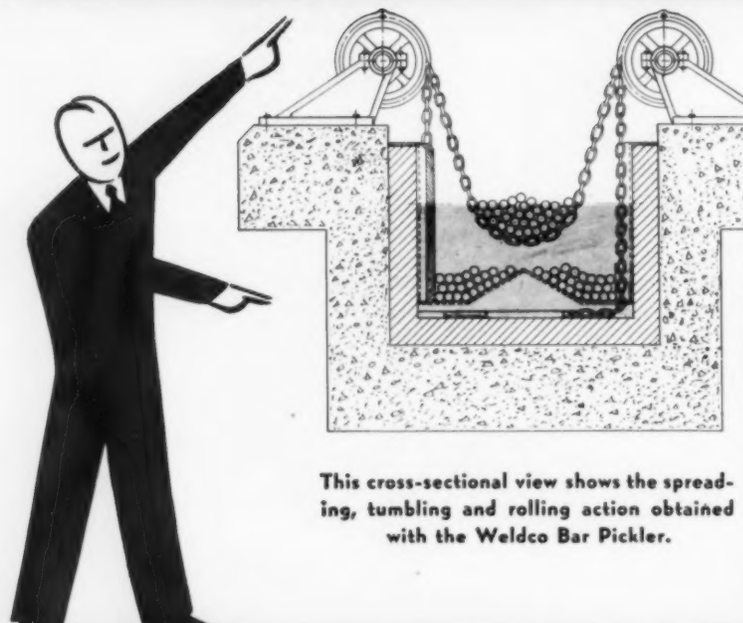
Total cost of the installation was recovered in three years, according to G-E engineers, and net annual project savings over the old handling method amount to $15,000. Other advantages include better housekeeping and a 50 per cent reduction in floor space requirements.

TEMPLET REPRODUCTION

▲"Visual" Planning Equipment Co., Inc. has just announced its "Repro-Templet System." This is a complete method for securing blueprints or photographic prints directly from "Visual's" 3-dimensional layouts.

A photographic film templet, coated with a pressure-sensitive cement, is now furnished to match each piece in the model layout. Once the layout is complete, the "Visual" Photo-Repro-Templets (patent applied for),

For economical, time-saving pickling
the *New* WELDCO Mechanical Picklers
save Man power, Maintenance and Money



This cross-sectional view shows the spreading, tumbling and rolling action obtained with the Weldco Bar Pickler.

If you're pickling round, hexagon or square bars, coils, flats, tubing or sheets, the Weldco Mechanical Picklers are your best bet to increase tonnage at reduced cost. Easy to operate and control, the Picklers save 40 to 60 percent pickling time by combined mechanical agitation and chemical action, and eliminate the use of an overhead crane and operator. All surfaces are equally exposed and over-pickling is eliminated by a pre-determined cycle.

Weldco engineers can furnish all facilities for your entire pickling department, including our new, inexpensive, floor-operated crane. Write or phone today for further information.

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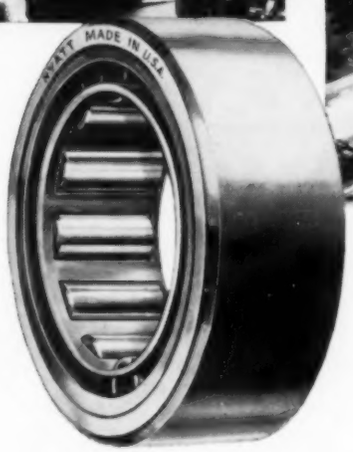
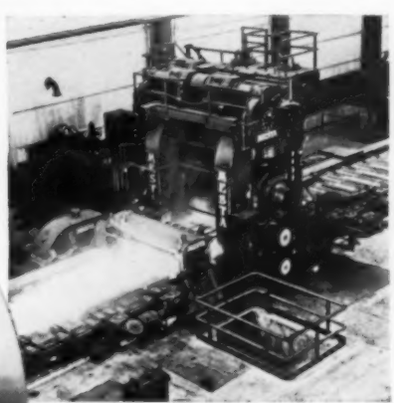
In recent months, the steel industry has been setting production records in excess of 9,000,000 tons a month—and it is aiming still higher.

To attain and maintain such a high production level, operating equipment must necessarily be at peak performance at all times.

And to help keep the mills operating successfully at this continuous pace, Hyatt Roller Bearings are serving and saving in tables... cars... cranes... mill motors... and other auxiliary equipment.

Thus proved by performance, easing shock loads, extending equipment life, and reducing operating costs, Hyatts are the preferred steel mill bearings for new equipment or changeovers. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J.; Chicago, Ill.; Pittsburgh, Pa.; Oakland, Calif.





HYATT ROLLER BEARINGS

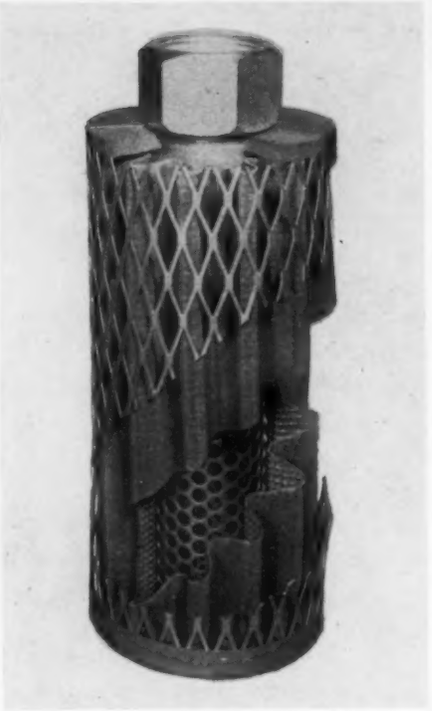
affixed to a film grid sheet, become the master from which as many prints as needed may be secured.

Based on the statements of top Kaiser-Frazer engineers, the new "Visual" process saved 26,000 man-days of planning and layout time in the current conversion of the plant at Willow Run.

SYNCLINAL FILTER

▲ Efficient design that concentrates great filtering capacity into small space to permit longer periods of production between cleanings, simplicity that permits quick on-the-spot cleaning by ordinary workmen, and versatility to fit a wide range of demands—these are the features of Marvel Engineering Co. synclinal filters now used as equipment by over 200 manufacturers of machines.

The basic filtering element is a synclinally folded wire cloth cylinder backed by a heavier wire screen reinforcement. Outer metal housing protects the fine filtering element from accidental bumps or scrapes which might cause holes and reduce filtering



value. The perforated center tube is welded to the base plate and is threaded on top for the hex nut coupling. The coupling nut has the double function of attaching the unit to the inlet pipe and of holding together the entire assembly. Removing this hex nut frees all parts for easy cleaning, reassembly and immediate reuse.

The same basic element is available in both sump and line models. The line model has an outer housing enclosing the unit and a head casting to fit into the pipe line. Removing a single hand nut releases the filter without disturbing pipe fittings. These filters may be used wherever it is important to clean foreign matter out of non-corrosive liquids as in all hydraulic and low pressure systems. They operate in any position.

A typical pour test by Phoenix Chemical Laboratories showed a Marvel synclinal filter flow rate of over three times that of a like size conventional circular type filter. Individual capacity sizes are available from 5 to 50 gpm, and multiple installation is easily made to meet needs for greater capacities. Wire mesh elements can be had in screen sizes from a coarse 30 to fine 200 mesh.

NICKEL CONSERVATION

▲ In line with the company's policy of conserving nickel supplies as far

engineered for "Time-Cost" Saving

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each junction-box type has four tapped hubs and three plugs — E, C, L, T, and X fittings in one — making installation.

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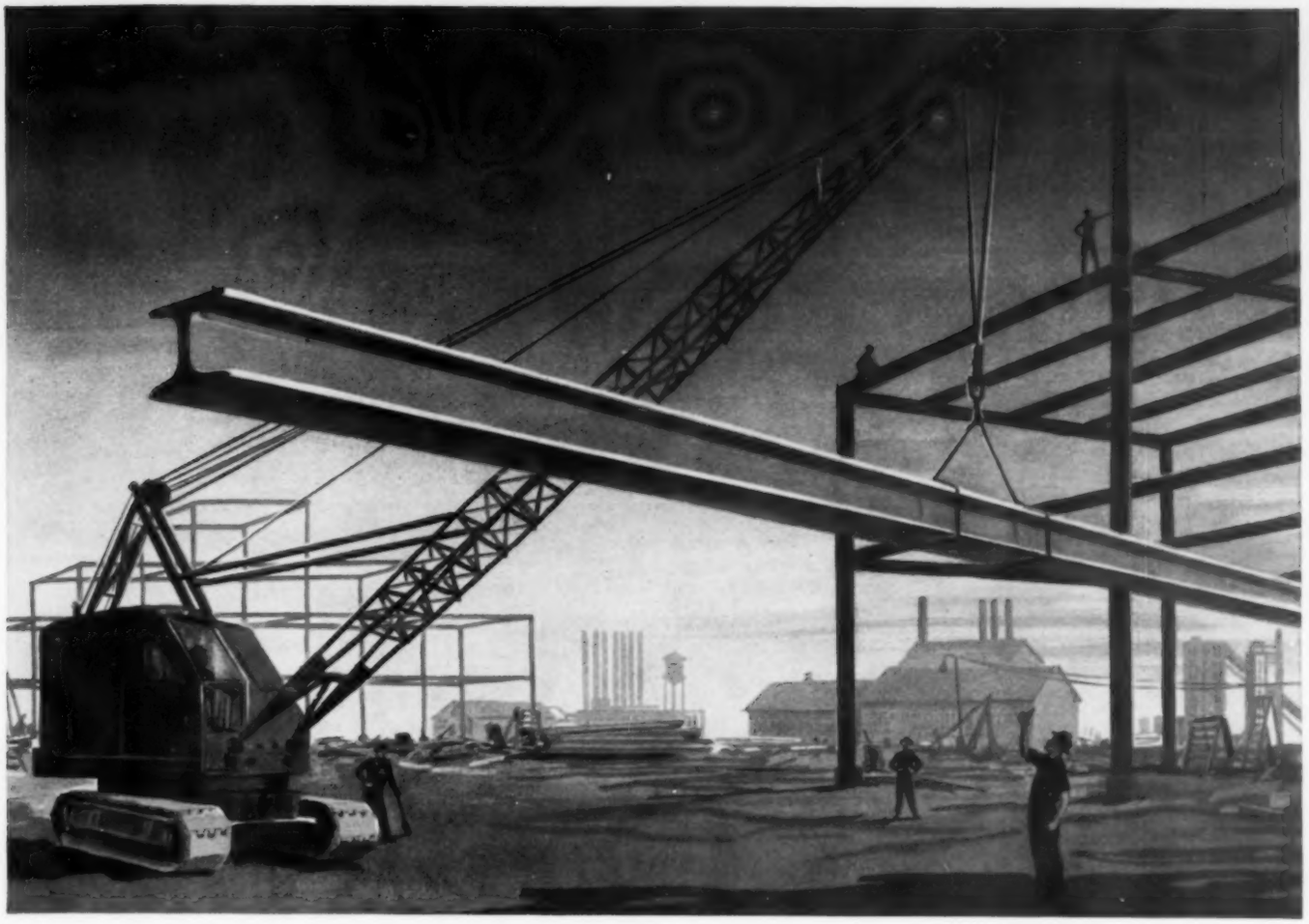

KULJIAN ENGINEERING gives a lift to STEEL

"Giving a lift" to a neighbor is an old term for helping when an emergency arises. The demands being made on the Steel Industry today amount to an emergency of a kind in which the Kuljian organization is best fitted to "give a lift."

Increased production calls for plant extensions and modifications, all requiring engineering services of an experienced and specialized type. Kuljian offers its services to relieve the extra load on your regular engineering staff. Not only additional engineering manpower but seasoned competence and ability to assume complete responsibility for design and supervision of large projects, are made available at a time when they are most needed and hardest to find. Your phone or a letter will bring a Kuljian engineer to your desk promptly for consultation without obligation.

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The **Kuljian** *Corporation*

ENGINEERS

1200 NORTH BROAD STREET, PHILADELPHIA 21, PA.

as possible during the current period of emergency, International Nickel Co. announced the development of an alloy for use under conditions of high temperature and corrosion.

The new alloy, trade-named "Incoloy," contains about 35 per cent nickel and 20 per cent chromium, with the balance iron. It is produced in most standard rolling mill forms, including sheet, strip, rod, wire and tubing. This alloy is designed for many purposes now served by some of the company's older alloys, which run up to more than 70 per cent nickel.

CONDENSATE RETURN UNIT

▲ Compactly designed to occupy a minimum of floor space, the new vertical Roth condensate return units are versatile for applications up to 8000 sq ft EDR at 20 psi. Two sizes cover this range.

The vertical condensate unit handles water to 210 F without vapor lock and the new vertical design is particularly intended for installations where the return piping is close to the floor level. Also, the unit can be installed in a shallow pit, when desired, without risk of flooding the motor which is mounted vertically above the pump and receiver.

This vertical condensate return unit handles water to 210 F without vapor lock.

The condensate return unit is supplied as a complete assembly including pump, choice of cast iron or steel receiver (10 or 15 gallon), enclosed float switch, single phase or three-phase 1750 rpm motor. Simplex or duplex units are available from Roy E. Roth Co.

DIRECT FLOW PUMP

▲ Aldrich Pump Co. announces the addition of a 6-in. stroke direct flow pump series to their over-all line. This series includes Triplex, Quintuplex, Septuplex and Nonuplex units, having 3, 5, 7 and 9 plungers, respectively. Ranging from 300 to 900 hp, the 6-in. stroke series covers numerous applications, such as heavy forging press service, steel mill descaling, etc.

These direct flow pumps operate at crankshaft speeds up to 300 rpm and are suitable for direct drive by engine or synchronous engine-type motor. The pumps feature inverted design and a direct flow fluid-end. All wearing parts are interchangeable among 3, 5, 7 and 9 plunger units. The fluid-end is sectionalized in construction so that maintenance is simplified and inexpensive. Reduced space between valves affords higher volumetric efficiency; and changes in

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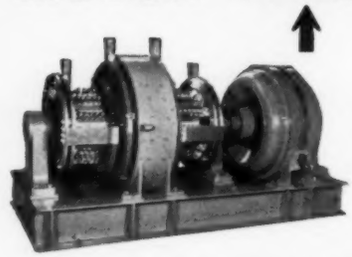
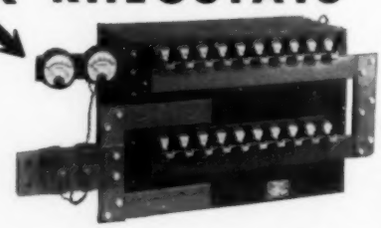


TANK RHEOSTATS



• TONG TEST AMMETERS
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... *plus* AMPLE CAPACITY

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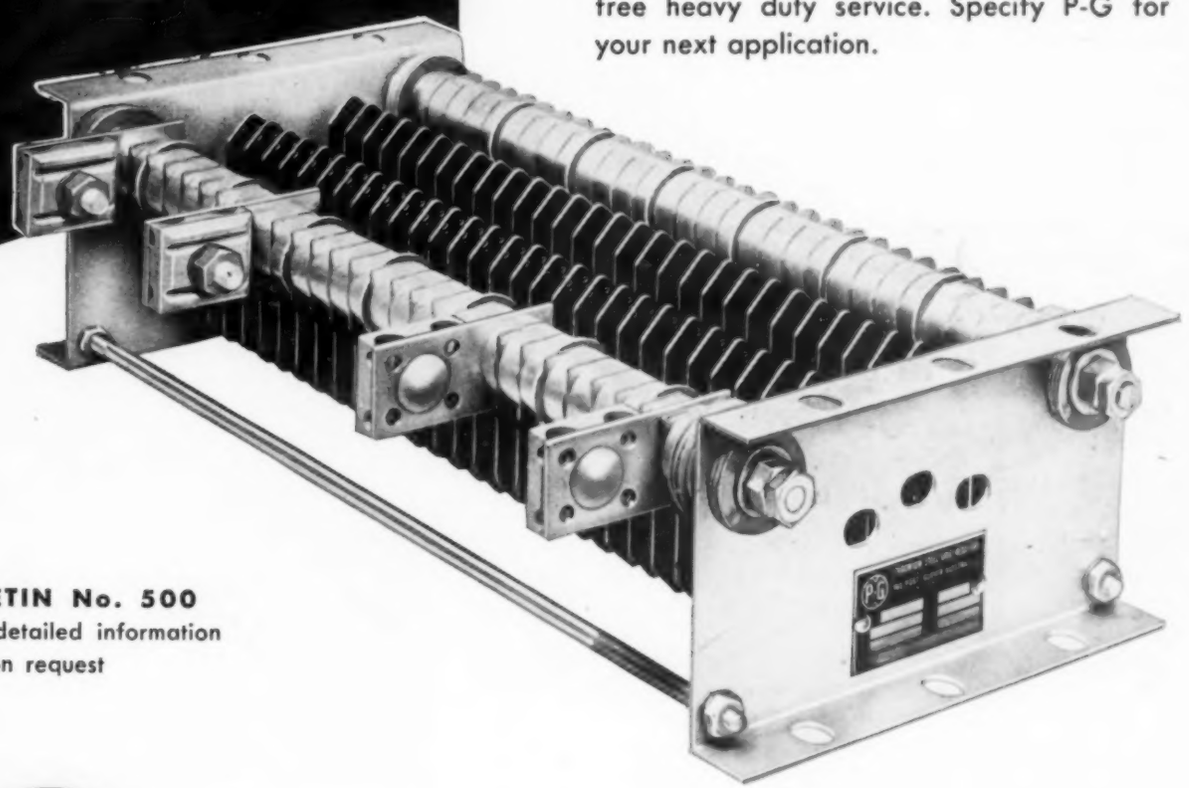
Use resistance grids punched from many gages of resistor steel. Thus it is easier for P-G to meet correct ohmic values and still furnish the capacities necessary for each job. Ability to meet both requirements is assurance of accurate control with full protection for your electrical equipment. All steel construction, mica insulation, with provision for expansion and ample ventilation give that extra stamina needed for trouble-free heavy duty service. Specify P-G for your next application.



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P-G

The Nonbreakable Steel Grid Resistor

THE POST-GLOVER ELECTRIC COMPANY

• ESTABLISHED 1892 •

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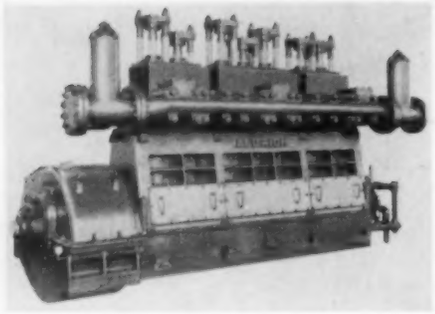


One application of this new pump is steel mill descaling.

plunger size can be readily made to meet alterations in pressure or capacity.

TAP CHANGING ASSEMBLY

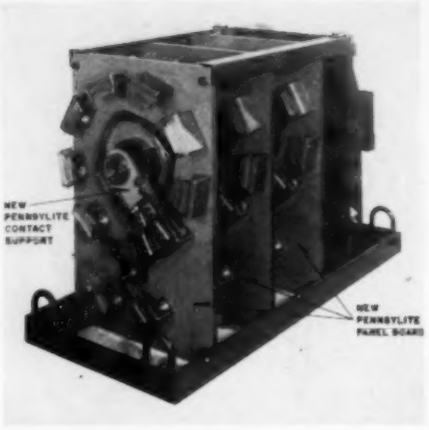
▲ A low power factor (low dielectric loss) laminated material, was recently developed by the Pennsylvania Transformer Co. for the switch assembly of Pennsylvania's 16 and 32 step underload tap changing equipment. This tap changing assembly is used in Pennsylvania's step voltage regulators, integral unit substations, and load ratio control transformers.

The remarkable new low loss "Pennsylite" was developed upon the suggestion and guidance of Pennsylvania Transformer Co. by both Mica Insulator Co. and National Vulcanized Fibre Co.

In the past, considerable difficulty has been experienced with existing fabric and paper base laminates. Under electrical stress, voltage found its way through the void structures parallel to the lamination in the insulating materials used in underload tap changing equipment, destroying the insulating value of the laminates used.

The 60 cycle power factor method of evaluating "Pennsylite" has been adopted as the standard method for evaluating new laminated material. Low power factor results in low dielectric loss, and means that localized heat is not generated near the studs and electrodes used in underload tap changers.

For "Pennsylite," the power factor remains constant up to 10 kv stress,



The 60 cycle power factor method has been adopted as the standard for evaluating new laminated material.

and rises only a few per cent for 15 kv stress when tested in accordance with ASTM designation D-50-47T after conditioning for 24 hours at 100 C. It has good aging characteristics, will not blister or delaminate in hot oil up to 120 C. The dielectric strength of ¾ in. thick "Pennsylite" for 3½ in. spacing, with ½ in. diameter pins under oil shows a withstand dielectric strength of 125 kv. Visible corona

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... and in the BEST quality*

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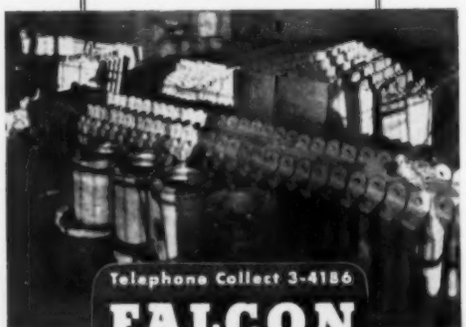

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***with the* "SAFETY" BOX TYPE HOLDER**

Mark ladle-test pieces with furnace number, year-code letter and heat numbers—in 50% less time with this type holder. Complete mark is made with one blow. Marks are in straight line, of even depth, easy to read—reduces errors in stamping and identifying tests. Eliminates danger of hitting fingers with hammer. *Write for proposal on your needs.*

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BUCKET HANDLING CRANES

When your Bucket Handling Cranes, whether Travelers or Gantries, are "Shaw-Box," you can anticipate impressive records of efficient, low cost handling with minimum maintenance expense. Their outstanding performance is insured by the through-and-through quality that results from "Shaw-Box" experience, engineering excellence, and precision manufacturing techniques. The rugged "Shaw-Box" construction details makes each of them prominent examples of the interpretation steel men can obtain from their individual mill or AISE crane specifications. Years of working with steel men has given "Shaw-Box" an intimate understanding of mill crane requirements. "Shaw-Box" Bucket Handling Cranes are designed to withstand this severe service. For the service they give, "Shaw-Box" Bucket Handling Cranes offer exceptional value for your crane dollar.

Be sure to send all your inquires for Steel Mill Cranes and Soaking Pit Carriages to "Shaw-Box."

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SHAW-BOX CRANE & HOIST DIVISION
MUSKEGON, MICHIGAN

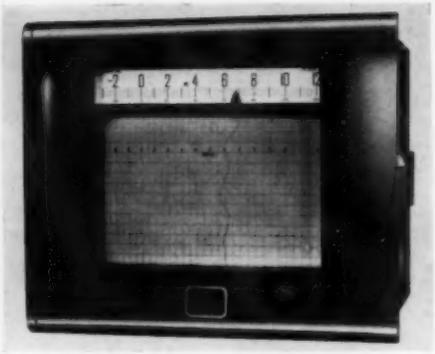
Builders of "Shaw-Box" Cranes, 'Budgit' and 'Load-Lifter' Hoists and other lifting specialties. Makers of 'Ashcroft' Gauges, 'Hancock' Valves, 'Consolidated' Safety and Relief Valves, 'American' Industrial and 'Micrasen' Electrical Instruments.

under this test appears at 110 kv which designates the threshold or ionization point and also illustrates homogeneous structure of the material.

STRIP CHART INSTRUMENT

▲ Bristol Co. announces the development of a new line of strip-chart electronic instruments, described as the Series 500 strip-chart "Dynamaster" electronic instruments. The instrument is a high-speed, self-balancing a-c bridge designed for measurement of temperature, resistance, conductivity, strain, position, inductance, pressure, force, or any other variable which can be measured in terms of impedance. In addition, the instrument can be used for electric power totalization and as the receiver for Bristol's "Metameter" system of telemetering.

The measured variable is recorded on a chart 11¼ in. wide and indicated on a large scale which is legible at a distance. In addition to the single record model, instruments are available for as many as 16 different records on the same chart. Models are offered for



The instrument is a high-speed, self-balancing a-c bridge.

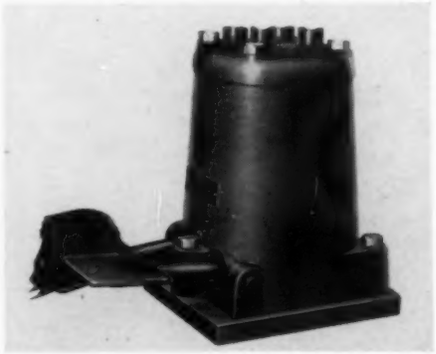
full-scale pen travel in 7 seconds, 3 seconds and ⅔ seconds, with a full range of standard chart speeds from 1 in. per hour to 120 in. per minute. Supplementing the recording instruments, Bristol also announces a complete line of automatic controllers, including both electric-operated types and free-vane pneumatic types.

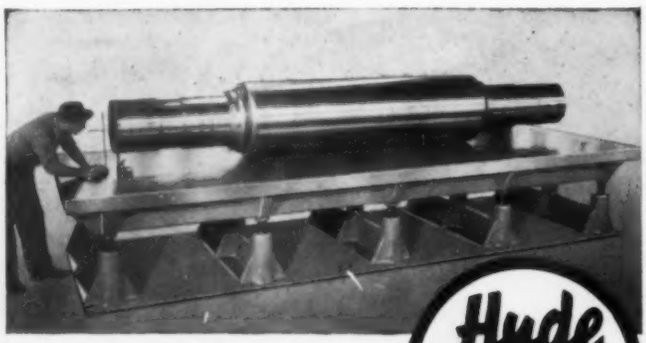
All of these strip-chart instruments are housed in a moisture-, fume-, and dust-proof case suitable for wall, flush-panel, or front-of-panel mounting. The scale and recording mechanism are mounted on the front of a hinged aluminum alloy panel, which is easily swung out to gain access to the electronic components or the control mechanism.

FOOT-OPERATED VALVES

▲ "Quick-As-Wink" foot-operated valves permit hammers, shears, presses, hopper gates, furnace doors, and all other types of air operated machinery and equipment to be fully controlled simply by foot pressure on a pedal. Consequently, the operator has both hands free to handle the

The foot-operated valve leaves operator's hands free to handle work.





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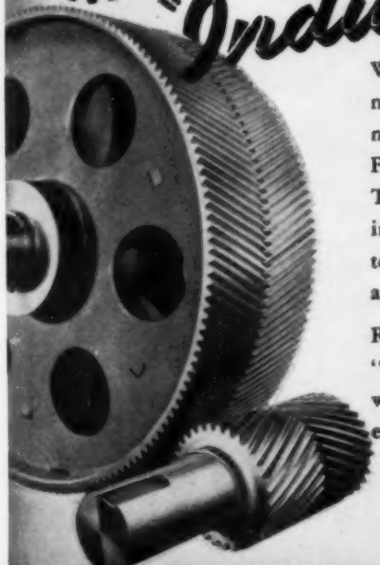

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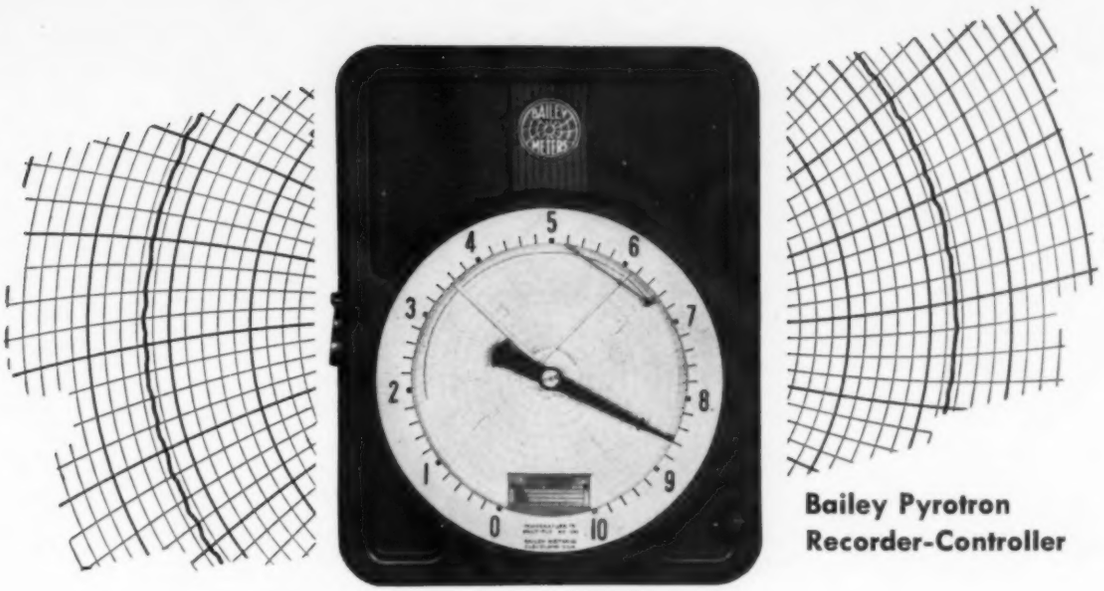

Bailey Pyrotron Recorder-Controller

Looking for Better Temperature Instruments?

...Then check these features of Pyrotron Electronic Resistance Thermometers...

FUNDAMENTAL ACCURACY

Bailey Pyrotron Resistance Elements are made of highest purity platinum—the material used by the National Bureau of Standards in establishing basic standards for temperatures from −190°C to +660°C.

THREE TYPES OF CONTROL

Pyrotron Controllers may operate: on-off electrical systems by either electronic relays or electric contacts, modulated electronic systems, or air-operated systems. Two temperatures may be recorded on the same chart and controlled by a single instrument.

FACTS PUT INTO USABLE FORM

Bailey Pyrotrons may be arranged to put temperature facts into convenient usable forms. If two or more temperatures are related, they may be recorded as continuous records on the same chart for easy comparison. The average of several temperatures or the difference between two temperatures may be recorded as a single continuous record which may be retransmitted to a distant point or used to actuate a control system.

EASY INSTALLATION

Bailey Pyrotrons do not require careful leveling or protection against vibration. Three ordinary copper wires are all that is needed to connect each temperature sensitive element with the recorder. Power may be taken from any 115 volt 60 cycle circuit.

MINIMUM MAINTENANCE

The absence of galvanometers, batteries and standardizing equipment, together with the use of interchangeable unit assemblies, reduces Pyrotron maintenance to the vanishing point.

ABUNDANT POWER

A separate motor drive for each temperature furnishes abundant power to operate a recording pen, a controller and an alarm switch.

For the full story on this unusual electronic resistance thermometer which is suitable for ranges between −300°F and 1200°F, ask for Bulletin No. 230-C. P-21

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The valving mechanism, manufactured by C. B. Hunt and Son, Inc., has a stainless steel body and push-pull rods, brass sleeves, self-sealing U-shaped packers and many other refinements found only in this valve construction. All operating parts are fully enclosed against the entrance of dust and dirt, and protected within a sturdy cast iron housing, assuring long, efficient, trouble-free operation. There is no metal to metal seating. All parts are in pressure balance, eliminating creeping and crawling. Pipe connections are made conveniently through the top of the housing.

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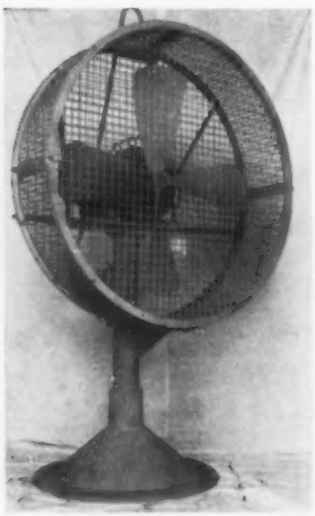

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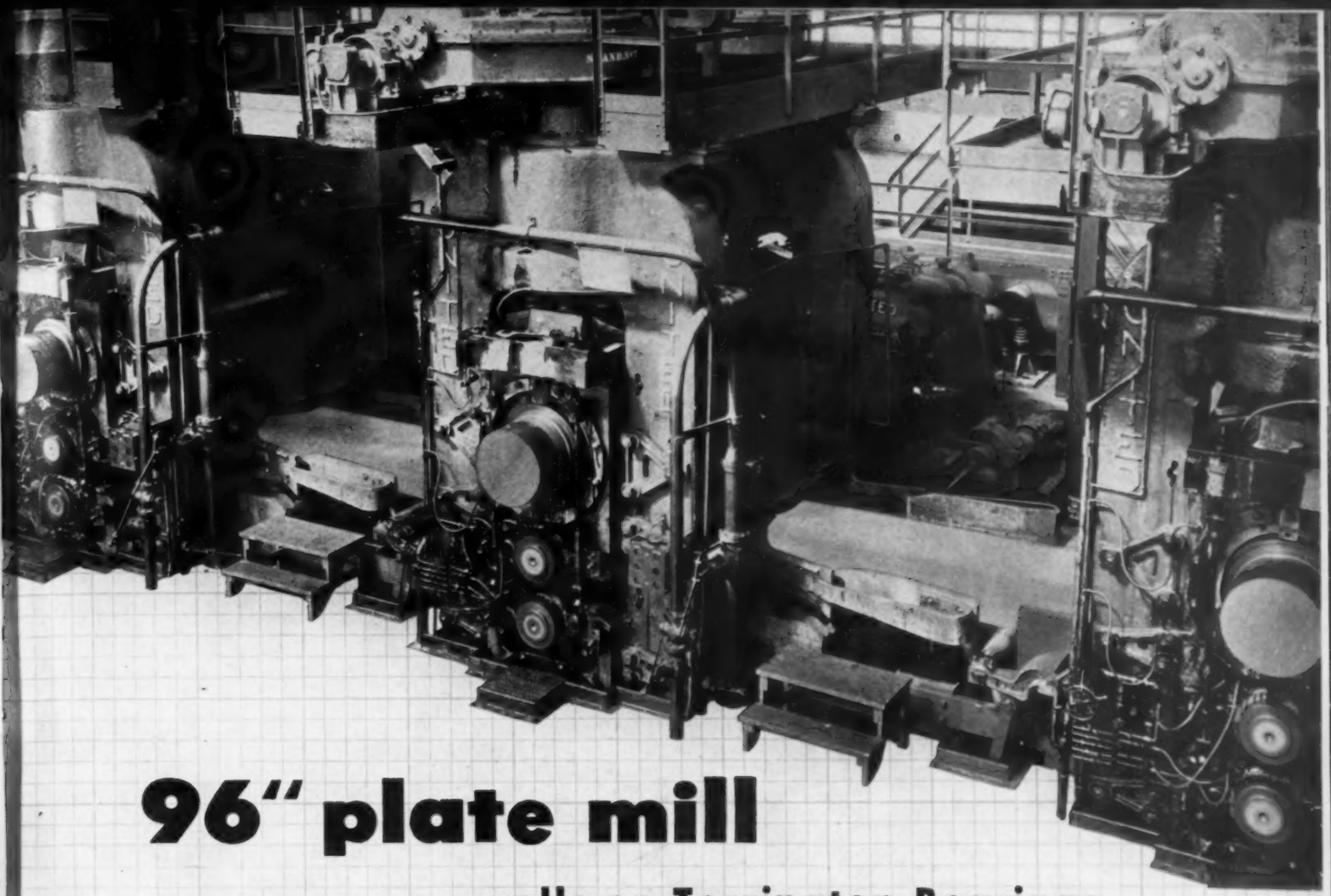
AIR FILTER

▲ A new high velocity unit air filter, "Type HV," has been introduced by American Air Filter Co., Inc. It is made of corrugated strips of fine mesh wire in which the corrugations taper so that when two strips are placed together they form a series of pyramid shaped pockets. The small ends of the pockets are closed to the air flow to eliminate any open air passages through the media.

These filters are designed to operate at velocities up to 500 fpm and maintain a uniformly high cleaning efficiency over a wide range of air velocities. They can be serviced in the conventional way with washing and charging tanks or reconditioned by washing out the accumulated dust with a hose and spraying with filter adhesive.

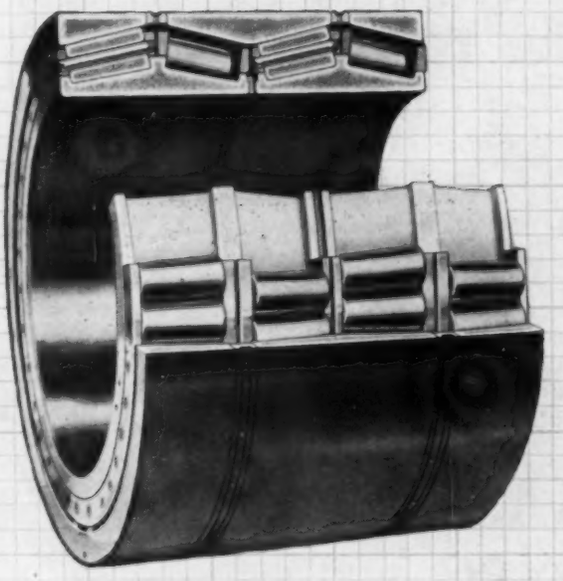
SAFETY TONGS

Ten-ton coils of strip steel are handled easily and safely at the Rouge plant of the Ford Motor Co. through the aid of these massive tongs especially designed for the job by Heppenstall Co. Remarkable delicacy in handling was a "must" imposed by Ford officials, as material has to be moved without damaging edges of the coil. As with other Heppenstall tongs designed for Ford Motor Co., safety in the operation is assured, because the tongs eliminate the need for a ground crew to fasten the load. The signalman in the picture merely spots the location for the craneman.



96" plate mill

rolls on Torrington Bearings



Torrington Roll Neck Bearings in this 96" Plate Mill at United States Steel Company's South Works help produce high tonnages of quality steel.

Four rows of closely-spaced rollers provide high radial and thrust capacity, while the reduced cross-section of Torrington Bearings permits larger roll neck diameters for greater rigidity and strength. Torrington Bearings are manufactured by experienced craftsmen—from selected alloy steel. Special heat-treating procedures assure long service life.

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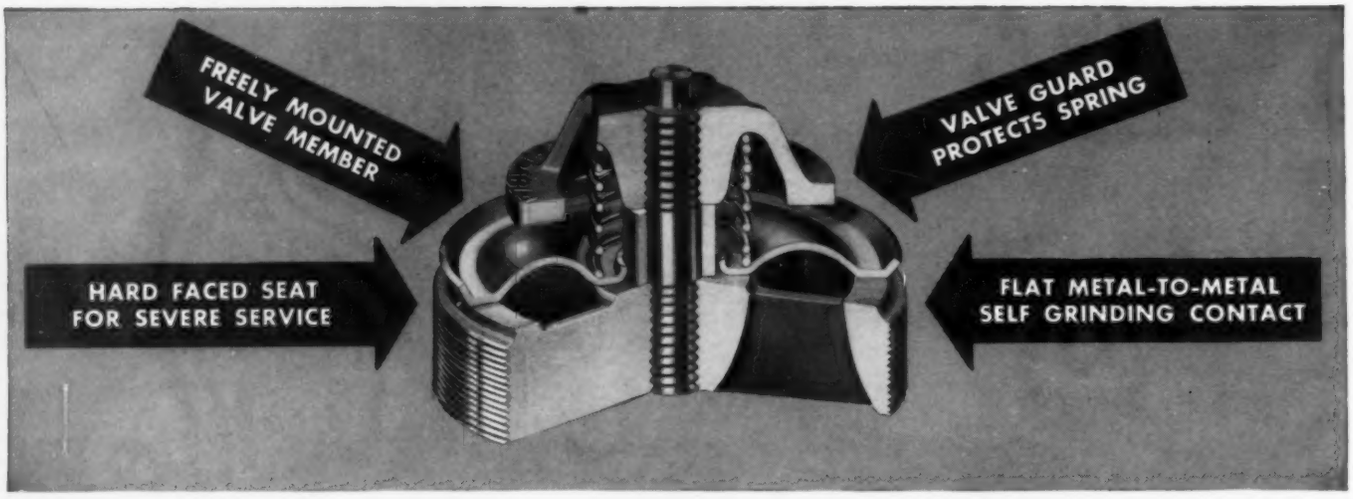
FREELY MOUNTED VALVE MEMBER
VALVE GUARD PROTECTS SPRING
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FLAT METAL-TO-METAL SELF GRINDING CONTACT

1 **THEY ARE SELF-GRINDING:** Durabla Valve Units*, utilizing the freely mounted arched construction valve member exclusive to Durabla, are self-grinding, as the flat portion of the valve member is in direct contact with the flat valve seat and is free to move about its axis, thus producing a constant self-grinding action.

2 **VALVE SEATS ARE HARD FACED FOR SEVERE SERVICE:** Providing a seat surface hardness of Rockwell C-48-52 (approximately 500 Brinnel) or more in special valves, Durabla Valve Units have a long record of effective service with FLUIDS CARRYING SUSPENDED ABRASIVE SUBSTANCES. The metal valve member effectively prevents the pitting or "pick-up" of abrasive substances sometimes occurring with valves made of other materials.

3 **VALVE SPRINGS AND VALVE STEMS ARE PROTECTED:** The Valve Guard protects the Valve Spring from ever compressing more than 50% of its length. The Valve Stem is protected against breakage by the free mounting of the Valve Member.

Economy, efficiency and adaptability, based on long established service records and exclusive design make Durabla Valves your guarantee of reliable, uninterrupted pump operation.

You can specify Durabla Valves when you order a pump, (many manufacturers use them as standard equipment), or you can order Durabla Valves to fit any type of reciprocating pump, (they come with drive-fit seats or threaded seats with or without a shoulder to suit the job).

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FORD MOTOR PLANS $43,000,000 EXPANSION

▲ A $43,000,000 expansion and modernization of steel operations in Ford Motor Co.'s Rouge plant at Dearborn, Mich., which will add 190,000 tons of finished steel capacity annually for defense and civilian use, was announced.

The program, now underway, will increase the total output of Ford finished steel by about 18 per cent. The program is expected to be completed by March 1953.

Scheduled are 37 new coke ovens, a new sinter plant, installation of new pig casting equipment and extensive improvements in the open hearth and rolling mill facilities.

Contracts for construction and installation of the multi-million dollar project will be signed with 43 separate companies.

A portion of the increased coke capacity will be used to supply the new Ford foundry in Cleveland. Because foundry capacities were so critical during World War II, Ford is backing up foundry capacity with added coke facilities.

In addition to facility and by-product improvement, a new 647-foot ore carrier is to be completed for the start of the 1953 shipping season on the Great Lakes. It will be the third Ford Motor Co. vessel in lake service.

Alterations in the blooming mill will permit rolling of slabs up to 60 in. wide. Coil weights in the cold rolling mill will be increased an average of 87 per cent.

It was pointed out that the expanded output can be reached quickly with a minimum use of critical materials and will give Ford Motor Co. well-balanced steel production facilities.

Ford steel production ranks among the first ten in America. In spite of expansion, however, Ford will continue to buy nearly 50 per cent of its steel.

CHILEAN STEEL FIRM PLANS NEW COKE OVENS

▲ Pacific Steel Co. of Chile will build a new battery of 13 chemical-recovery coke ovens at its plant near Huachipato, Chile.

Design and materials for the new ovens will be supplied under contract by Koppers Co., Inc. The integrated steel mill at Huachipato already has a battery of 57 ovens which was built by Koppers two years ago.

The new ovens will be of Koppers-Becker design, the same type as in the present battery of 57. Pacific Steel Co's. complete plant has been in operation only a little more than a year and the new coke battery represents the first expansion of the original plant.

LONE STAR STEEL ORDERS MORE EQUIPMENT

▲ Lone Star Steel Co. of Dallas, Tex., has ordered more than $4,000,000 of General Electric equipment. Included in the order are a complete main drive and edger drive motors and controls and ventilating equipment for a new 45 × 80-in. two-high reversing slabbing and plating mill. A 15,000-kw steam turbine generator set and electrical distribution equipment will be furnished for plant-wide power supply.

The 7000-hp reversing main drive will consist of two G-E 3500-hp, d-c amplidyne-controlled motors, while a 2500-hp, d-c motor will drive the vertical edger. An 8000-kw flywheel motor-generator set will supply power to the motors.

A wound rotor motor will be furnished for driving the m-g set, a complete complement of exciter sets, mill control equipment including protective air circuit breakers, and downdraft recirculating ventilating equipment for the main drive.

Distribution equipment includes 13,800-volt metal clad switchgear, two 500-kw sealed ignitron rectifiers, seven unit substations and a master substation.

The mill is being built by the United Engineering & Foundry Co. It is expected to be in operation at Lone Star, Tex., by late 1952.

SINTERING PLANT FOR EASTERN STEEL MILL

▲ Westinghouse Electric Corp. will supply approximately $350,000 worth of electrical equipment for a new sintering plant, to be built for an East Coast steel mill. The plant will be used to convert iron-bearing materials from very small particles, unsuitable for blast furnace reduction, to large porous lumps, well suited for charging blast furnaces.

Roll scale and dust from the mill, fine ore, and flue dust from the blast furnace are mixed with coke and spread on a moving grate, where the mixture is ignited and sintered. A large volume of air is drawn through the burning mixture as the grate moves. At the end of the sintering machine, a rotating cooling tower is used to cool the sinter.

Control equipment in the new sintering plant will be interlocked to prevent pile-ups due to failure of electrical or mechanical equipment. This also will insure the proper sequence of starting and stopping the sintering operations. Equipment will be controlled from a central control board, which will have a flow diagram and indicating lights to show the operator what is going on in all parts of the plant — including a conveyor system that extends over a 900 by 300-ft area.

The order includes a-c motors and control, power centers for stepping down from 6.6 kv to 440 volts, an ignitron rectifier and d-c switchgear to feed an existing ore bridge, and 6.6-kv metalclad switchgear for controlling two fan motors and the ignitron rectifier transformer.

INDEX TO ADVERTISERS

AUGUST, 1951

A

Adalet Manufacturing Co., The 184
Aetna-Standard Engineering Co., The 1
Alliance Machine Co., The 6
Allis-Chalmers Manufacturing Co. 14, 15
American Bridge Co. 164
American Chemical Paint Co. 158
Atlas Mineral Products Co. of Pennsylvania 170

B

Bailey Co., Wm. M. 156
Bailey Meter Co. 191
Bantam Bearings Division of The Torrington Co. 193
Bedford Foundry and Machine Co. 184
Birdsboro Steel Foundry and Machine Co. 159
Bliss Co., E. W. 27
Bloom Engineering Co. 43
Bonnot Co., The 36
Bristol Co. 169
Browning and Co., Inc., Victor R. 186

C

Cities Service Oil Co. 3
Cleveland Crane and Engineering Co. 44
Cleveland Worm and Gear Co., The ..... Cover 3
Columbia Electric Manufacturing Co. 186
Continental Foundry and Machine Co. 4, 5
Crane Co. 173
Cunningham Co., M. E. 188
Cutler-Hammer, Inc. ..... Cover 2

D

De Laval Separator Co. 26
De Laval Steam Turbine Co. 42
Documentation & Licenses, Paris, France 48
Dowell, Inc. 144
Dravo Corp. 166
Durabla Manufacturing Co. 194

E

Electric Controller and Manufacturing Co. 7, 181
Electric Furnace Co., The 160
Electric Service Manufacturing Co. 39
Electric Storage Battery Co. 20
Elliott Co. 33

F

Falcon Bronze Co. 188
Farrel-Birmingham Co., Inc. 141
Flinn & Dreffein Engineering Co. 48
Foote Brothers Gear & Machine Corp. 11
Furnace Engineers, Inc. 151

G

General Electric Co. ..... Cover 4
Gulf Oil Corp. 21

H

Hallden Machine Co., The 48
Hunt and Son, Inc., C. B. 160, 161
Hyatt Bearings Division, General Motors Corp. 183
Hyde Park Foundry and Machine Co. 190

I

Industrial Gear Manufacturing Co. 190

J

Johns-Manville Corp. 32
Jones Foundry and Machine Co., W. A. 174

K

Koppers Co., Inc. 153
Kuljian Corp., The 185

L

Leeds and Northrup Co. 12, 13
Lewis Foundry and Machine Div., Blaw-Knox Co. 8, 9
Link-Belt Co. 198
Lintern Corp. 168
Loftus Engineering Corp. 35

M

Manning, Maxwell and Moore, Inc., Shaw-Box Crane and Hoist Div. 189
Markal Co. 161
Marvel Engineering Co. 167
Mathews Conveyer Co. 150
Mesta Machine Co. ..... Cover 1
Metal & Thermit Corp. 19
John Miles & Partner (London, Ltd.) 48
Minneapolis-Honeywell Regulator Co. (Industrial Div.) 176, 177
Morgan Construction Co. 142
Morgan Engineering Co. 178
Murray Manufacturing Co., D. J. 170

N

National Bearing Division, American Brake Shoe Co. 34
National Carbon Co., A division of Union Carbide and Carbon Corp. 28, 162
National Electric Coil Co. 157
National Roll & Foundry Co. 2

O

Oakite Products, Inc. 172
Ohio Electric Manufacturing Co., The 148
Ohio Steel Foundry Co. 165
Okonite Co., The 25

P

Pennsylvania Transformer Co. 171
Pittsburgh Lectromelt Furnace Corp. 50
Pittsburgh Rolls Division, Blaw-Knox Co. 10
Poole Foundry and Machine Co. 18
Post-Glover Electric Co. 187
Pyle-National Co. 147

R

Reliance Electric and Engineering Co. 41
Ross Carrier Co., The 152
Rust Furnace Co. 139
Rust-Oleum Corp. 175

S

Salem-Brosius, Inc. 40
SKF Industries, Inc. 29
Square D Co. 38

T

Taylor Sons Co., Chas. 46
Timken Roller Bearing Co., The 16
Truflo Fan Co. 192

U

Union Carbide and Carbon Corp., National Carbon Co. 28, 162
United Engineering and Foundry Co. 17

W

Wagner Electric Corp. 24
Waldron Corp., John 154
Wean Engineering Co., Inc., The 48
Wean Engineering Co. of Canada, Limited, The 48
Wean Equipment Corp. 48
Westinghouse Electric Corp. 22, 23, 30, 31
Wilson Engineering Co., Inc., Lee 37

Y

York Engineering & Construction Co. 180
Youngstown Alloy Casting Corp. 155
Youngstown Foundry and Machine Co. 47
Youngstown Welding and Engineering Co. 182

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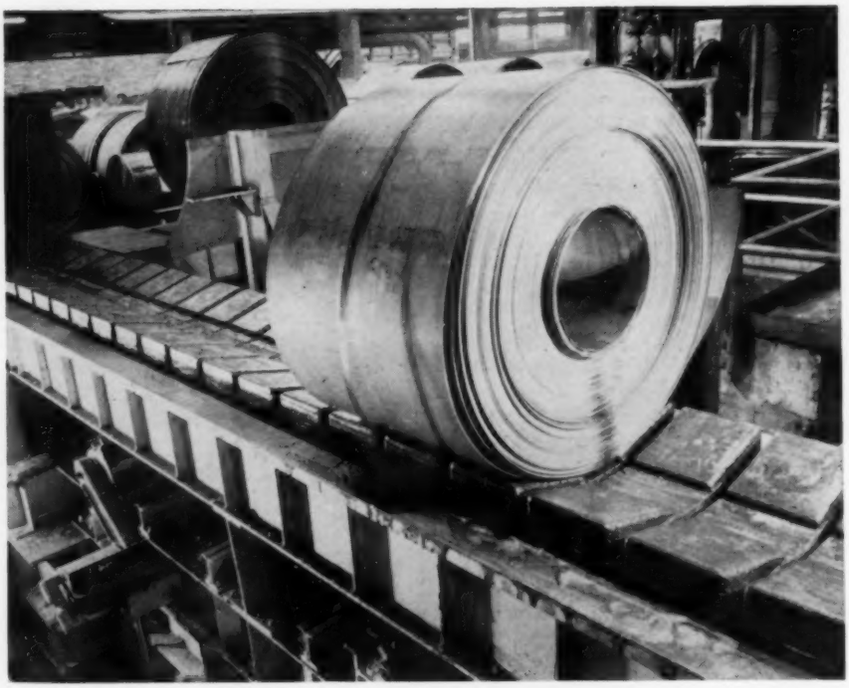
Link-Belt conveying systems eliminate hours of lost time. Coils travel close together, eliminating bottle-necks. They're handled gently, preventing edge damage. Down-time is reduced.

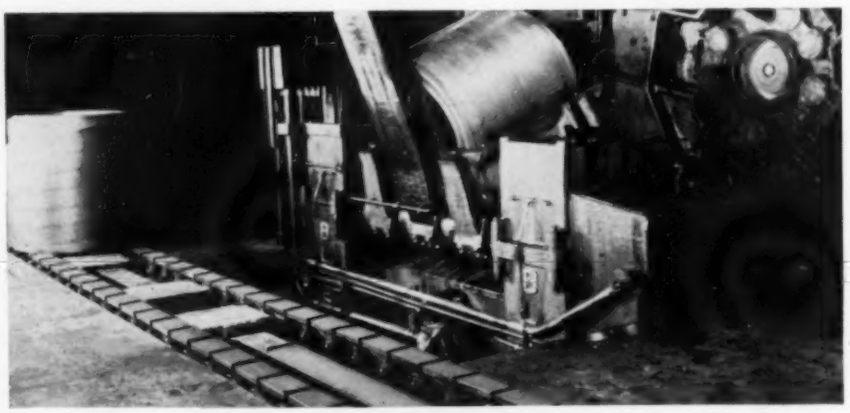
The physical work of crews is reduced. Link-Belt auxiliary devices transfer coils from one conveyor to another, turning, lowering, tilting, and weighing them with ease and precision. This increased mechanization means greater safety for workers.

It pays to call in Link-Belt while expansion is still in the planning stage. The Link-Belt engineer, working hand-in-hand with your own engineers, consultants and builders of mill and process equipment, can help you solve your mechanization problems.

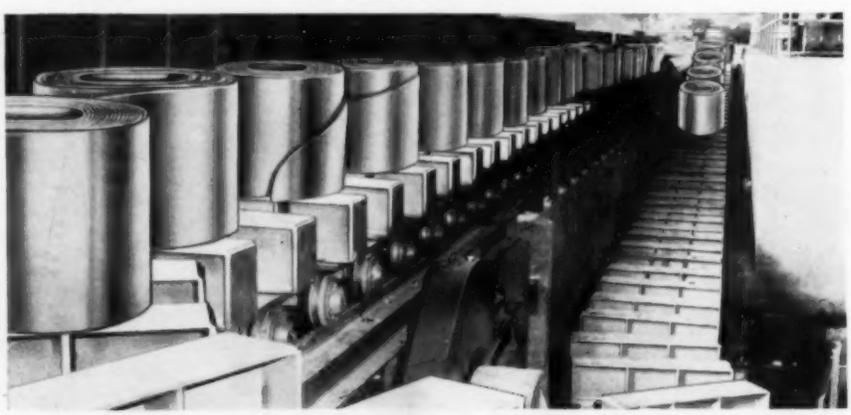
For a conveyor system planned to your specific requirements, contact your nearest Link-Belt representative.



Link-Belt V-top, 36-inch-wide heavy duty pallet conveyor at delivery end of continuous pickle line ahead of cold rolling mill, carrying 15-ton coils. Coils are carried on their sides without damage.



Link-Belt double-strand roller chain conveyor carries 76-inch coils from hot-strip coiler. Down-tilter lowers coil to Waffle-Top Loader. Other Link-Belt equipment transfers coils gently from one conveyor to another.



Where numerous turns are required or cooling space is limited, Link-Belt Car-Type Conveyors are best. Coil never leaves its car. Without rolling or scuffing of edges, coils go around corners, up and down inclines.

LINK-BELT

MATERIALS HANDLING, PROCESSING & POWER TRANSMISSION MACHINERY

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Performance measures value in a Cleveland

FOR nearly 40 years, Cleveland has concentrated on the manufacture of worm-gear drives.

In specializing on a single type of gearing, this Company has emphasized one value above others—dependability—measured by the yardstick of performance on the equipment of its customers.

Thousands of worm-gear drives, made in the earliest years of the Company's operations, are in service today. They do not wear out. They serve in every phase of American industry, drive every type of mechanical equipment where a powerful, trouble-free, right-angle drive is wanted.

For a full showing of the wide variety of sizes and capacities of Cleveland worm-gear drives available, write for new Catalog 201F. The Cleveland Worm and Gear Co., 3278 East 80th St., Cleveland 4, Ohio.

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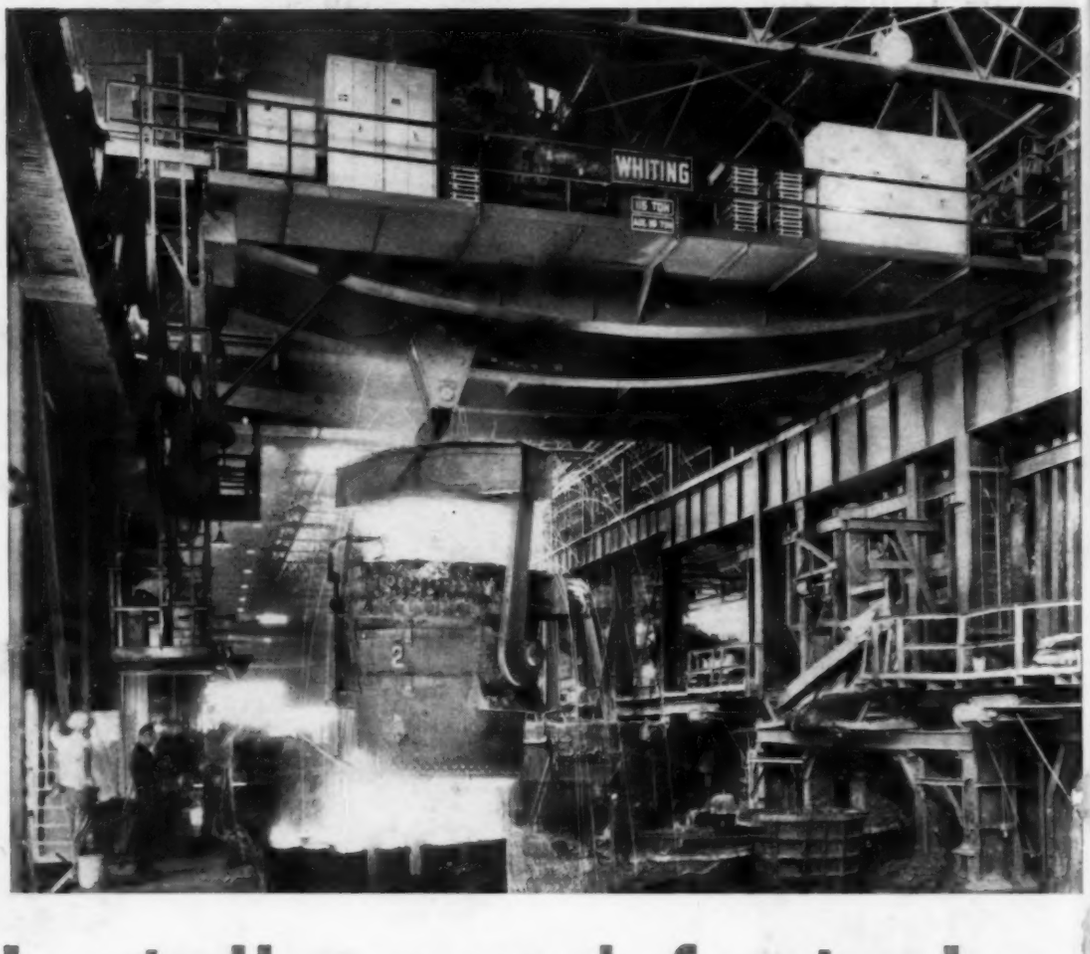
D-C CRANE DRIVES

Teeming is easy with new G-E d-c control which permits faster, more accurate positioning because of slow first-point lowering, no downward drift on first hoisting point.



"Heats" poured faster!

New G-E crane-hoist control—teamed with heavy-duty motors and fast-acting brake—permits safer, more accurate handling of new 115-ton ladle crane

Close-up of main trolley shows (at right) the 65-hp main hoist motor with newly designed G-E d-c magnetic brake for quick, accurate stops. At left is the 19-hp G-E trolley motor. Both motors are MD-600's—toughest G-E mill motors ever built.

Providing safer, more accurate control of this 115-ton ladle crane is the new G-E d-c crane control . . . control which has been *job-tested* on more than 50 tough-duty steel-mill installations. Here are a few of its features:

- Facilitates pouring by eliminating downward drift on first hoisting point.
- Slow light-load speed eliminates jarring of ladle when engaging hooks for pickup.
- Protects against cycling or pumping in limit-switch zone.
- Permits more accurate positioning because of slow first-point lowering.

Co-ordinated with the control are G-E MD-600 mill motors built to take the severe reversing duty required, and new fast-acting G-E d-c magnetic brakes for close jogging and precision spotting.

Whatever *your* crane drive problem, let a G-E steel-mill specialist help you reach a successful solution. For more data on G-E d-c crane drives, send for Bulletin GEA-5408. *General Electric Company, Schenectady 5, N. Y.*

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